Pennsylvania's Watershed Regions

Upper/Middle Susquehanna
Each of Pennsylvania’s major drainage basins has an array of individual characteristics that distinguish it from other regions of the state. These include diverse geographic and geologic features as well as major differences in historical settlement, economic and land use patterns. To reflect these variations, six regional water resources committees were created by the Water Resources Planning Act to ensure that individual regional priorities were developed and highlighted in the plan.

The committee members represent a broad range of interests in their region – business and industry, agriculture, local government and the environment. Each committee has identified and given consideration to a broad set of water resources issues and concerns specific to their region. The water resource management goals and objectives of the Upper/Middle Susquehanna Regional Water Resources Committee include:

- Protect important headwater habitats and recharge areas of the Upper/Middle Susquehanna basin
- Address the consequences of acidic drainages on receiving streams to improve and protect water quality, aquatic ecosystems and enhance the availability and utilization of water
- Provide guidance for the protection, preservation and development of existing and planned water supplies sources: Protect the quality and quantity of existing and planned water supply systems and improve the groundwater availability planning process to ensure continued development does not overtax, supply or unnecessarily hinder development.
- Promote integrated policies and programs to ensure a comprehensive approach to water resource management
- Reduce nonpoint source pollution through stormwater control and by promoting and utilizing land-based best management practices
- Promote the protection and conservation of our water resources to ensure sustainable supply of quality water for present and future human and ecological needs by protecting streamside/riverside corridors for recreation and water resource protection and by promoting regional economic development consistent with regional preservation and conservation objectives

The regional committee members will continue to work with DEP and other partners to make recommendations for attaining these goals.

### The Upper/Middle Susquehanna Region at a Glance

The Susquehanna River, in its entirety, is the 16th largest river in the United States and is considered “Pennsylvania’s River” for its importance as a source of drinking water, recreation and hydropower to millions of people in its watershed. The river starts at Otsego Lake near Cooperstown, N.Y., flows through Pennsylvania and Maryland, before emptying into the Chesapeake Bay at Havre de Grace, Md. This river is responsible for providing half of the freshwater received by the Chesapeake Bay. The Susquehanna River Watershed encompasses almost half of the state’s land area—more than any other river basin in the commonwealth—while Pennsylvania makes up more than three-quarters of the basin’s total area.

The Upper/Middle Susquehanna Region contains the largest sum of headwaters supplying the Susquehanna River Basin. Draining nearly 18,295 square miles, (including 6,275 square miles in New York) the Upper/Middle Susquehanna Region in Pennsylvania extends from the confluence of the West Branch of the Susquehanna River with the Susquehanna River at Sunbury north to the Pennsylvania/New York border. With a drainage area of nearly double that of the Lower Susquehanna Region, the Upper/Middle Susquehanna Region supplies the main stem of the Susquehanna River with headwaters originating from past-glaciated highlands combined with clear and cold mountain streams.

The Upper/Middle Susquehanna Region and its headwaters are located in some of the largest and most densely forested areas in the state. The region is recognized for containing eight of 15 counties within the Pennsylvania Lumber Heritage Region. These forested areas are important to water quality; their beneficial traits are discussed in the Land Use Section of this region. Evidence of forested regions resulting in excellent water quality is also shown in the Upper/Middle Susquehanna Region Special Protection Waters Map. The density of high quality and exceptional value waterways is a direct result from being located in densely forested areas.

### Susquehanna River Facts

Possible meanings of “Susquehanna”: muddy current; mile wide, foot deep; the long reach river; long crooked river; the place of the straight river.

- **Basin Area:**
  - Total: 27,510 square miles
  - Upper/Middle Susquehanna River Basin: 18,295 square miles
- **Headwaters:** Otsego Lake, Cooperstown, N.Y.
- **Mouth:** Chesapeake Bay, Havre de Grace, Md.
- **Susquehanna River Length:** 444 miles (total)
Watersheds in the Upper/Middle Susquehanna Region

“Watershed” is a generic term used to identify an area of land that drains to a particular waterbody. Watersheds can vary in size, from the acreage that drains into a brook to a major river. For purposes of this atlas, watersheds are classified by a nested hierarchy based on landscape scale. A subwatershed is the land area that drains into a stream or river (or in some cases, two streams) and is the smallest in size in the classification hierarchy. Pennsylvania’s original State Water Plan divided the commonwealth into 104 subwatersheds, ranging in size from approximately 100 to 1,000 square miles, named for the major streams of the subwatershed. A subbasin includes all of the subwatersheds that drain into a particular reach of a larger watercourse. A basin encompasses all of the subbasins that drain into a major waterway. In Pennsylvania, there are six basins—Erie, Genesee, Ohio, Susquehanna, Potomac and Delaware—each with a different outlet. The Erie Basin empties into Lake Erie, the Genesee Basin contributes to Lake Ontario, the Ohio Basin drains into the Mississippi River, the Susquehanna Basin and the Potomac Basin drain into the Chesapeake Bay, and the Delaware Basin drains into the Delaware Bay.

A particular tract of land can belong in multiple watersheds, depending on the scale of the landscape. For example, in Clinton County, Sinnemahoning Creek is a tributary to the West Branch of the Susquehanna River, which is a tributary to the Susquehanna River. The land that encompasses the Sinnemahoning Creek Subwatershed is part of the Upper West Branch Susquehanna Subbasin, which, in turn is part of the Susquehanna Basin. The Subwatershed Map on the next page depicts the 23 watersheds found in five subbasins of the Upper/Middle Susquehanna Region.

Major Tributaries (in Pennsylvania)

- Chemung Creek
- Sugar Creek
- Towanda Creek
- Wysox Creek
- Wyalusing Creek
- Mehoopany Creek
- Tunkhannock Creek
- West Branch of the Susquehanna River

- Bowman Creek
- Lackawanna River
- Fishing Creek
- Sinnemahoning Creek
- Pine Creek
- Bald Eagle Creek
- Moshannon Creek

Points of Interest in the Region

- Cherry Hill State Park, the state’s first Dark Sky Park – Galeton, Potter County
- Pine Creek Gorge, the Grand Canyon of Pennsylvania – Wellsboro, Tioga County
- Wyalusing Rocks – Wyalusing, Bradford County
- Old Mill Village – New Milford, Susquehanna County
- Elk herd watching – Cameron and Elk counties
- Hang gliding at Hyner View State Park – Hyner, Clinton County
- Little League World Series – Williamsport, Lycoming County

Extreme Weather Conditions: Hurricane Agnes

Originating near Cozumel Island, Hurricane Agnes crossed the Gulf of Mexico and was headed east toward the Atlantic Ocean in June 1972. Instead of simply blowing over Florida, the hurricane switched direction and headed north and released heavy rains over the Atlantic states. By the time it hit Pennsylvania, Agnes was downgraded to a tropical storm, but carried billions of tons of water. In fact, Agnes brought some of the worst flooding to the middle-Atlantic States in American history.

The Susquehanna Basin has always been known as a flood prone area, due to various geological and topographical factors. When Agnes struck the region, no one could have predicted the severity of flooding that was to come. The Susquehanna River ran 30 feet above normal, and at Wilkes-Barre, the water flowed three feet above the level of the control dikes. Unprepared for the severe flooding, more than 100,000 residents of Wilkes-Barre left their homes and were relocated to safer areas. As the storm passed, nearly 330,000 were left homeless, 500,000 suffered property damage, and more than 5,000 square miles were submerged under water. In addition to the 122 lives lost, an estimated $4.5 billion of immediate damage hit the area.

While many residential areas were devastated, long-term economic strains permanently affected the area due to businesses lost. Residents moved away to regain employment in secure cities, leaving Wilkes-Barre to struggle with structural and industrial damages. Agnes has been classified as the one of the nation’s most costly disasters.
the region, generally receive the least amount of precipitation within the basin. According to the maps, Tioga and Bradford counties, in the northern part of Upper/Middle Susquehanna Region.

Regional Climate
The Upper/Middle Susquehanna Region has a moderate climate, lacking long periods of extreme hot or cold weather. A majority of the basin has a minimum temperature of 12 to 15 degrees Fahrenheit and a maximum temperature of 78 to 83 degrees Fahrenheit. Average annual precipitation for most of the basin ranges from 24 to 43 inches per year. Normal rainfall amounts are generally enough to support the vast agricultural lands of the region without irrigation. Although this registry information does not account for all water demands of the region, it provides useful information to predict areas of higher and lower demand, as shown by the Registered WaterWithdrawals Map. Consumptive water use, as defined by U.S. Geological Survey (USGS), is “that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, or removed from the immediate water environment.” The amount of water consumed in a region becomes an important consideration for resource management during times of drought or water shortages. On the Registered WaterWithdrawals Map, the pie chart within each subbasin depicts the percentage of each major sector of water use.

The maps on insertPage8 show Precipitation, Average Minimum Temperature and Average Maximum Temperature, averaged from 1961 to 1990, for the Upper/Middle Susquehanna Region. According to the maps, Tioga and Bradford counties, in the northern part of the region, generally receive the least amount of precipitation within the basin. These counties, along with Susquehanna County, also have the lowest average minimum temperature in the region, with most areas averaging 9 to 13 degrees Fahrenheit in January.

Regional Water Use
The demand for water throughout the region can be measured in part by compiling and mapping data contained in the registry of water users maintained by DEP. All public water supply agencies and hydropower facilities as well as anyone withdrawing more than 10,000 gallons of water per day are to register and report their usage to the DEP. There are no fees associated with registering and reporting.

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The pie chart on insertPage8 provides a breakdown of both consumptive and non-consumptive water use by sector for the Upper/Middle Susquehanna Region. Approximately 71 percent of water is used by utility and thermoelectric (power-generating) facilities, and 19 percent is used by public water suppliers. Industry use makes up approximately six percent, while mining, commercial facilities, and agriculture make up a combined four percent. This data is based on information available primarily from registrations submitted to DEP in 2003.
Precipitation

Upper/Middle Susquehanna Region Precipitation

Average Annual Precipitation (inches) 1971-2000

33 - 35
36 - 39
40 - 41
42 - 43
44 - 47
48 - 51
52 - 55
56 - 59

City/Town / River/Stream / Waterbody / County Boundary / State Boundary

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Average Minimum Temperature

Average Minimum January Temperature (°F)
1971-2000

- 9
- 10 - 11
- 12 - 13
- 14 - 15
- 16 - 17
- 18 - 19
- 20 - 21
- 22 - 23
- 24 - 27
In the entire Susquehanna River Basin, an estimated 500 million gallons of water are consumptively used every day. Public water supplies account for 200 million gallons a day, with losses from lawn maintenance, washing the car, evaporation from pools as well as leaks in water lines. Thermoelectric plants consume approximately 130 million gallons a day. A coal-fired or nuclear power plant evaporates a half gallon of water through its cooling tower to create the electricity needed to burn a 100 watt light bulb for 10 hours. At a consumption rate of 120 million gallons a day, agricultural operations are the fastest growing water use sector. In addition to the growing number of large animal feedlots, increasing amounts of water are used for irrigation as farmers try to improve the quality and productivity of their crops. Industry consumes about 30 million gallons a day. Hospitals, prisons, institutions and golf courses account for a combined 60 million gallons of water used every day.
Registered Water Withdrawals

Upper/Middle Susquehanna Region Registered Water Withdrawals

City/Town
River/Stream
Waterbody
County Boundary
State Boundary

Public Water Supply
Agriculture
Thermoelectric
Mining
Industry

Central West Branch Susquehanna River
35 Mgal/d

55%
33%
7%
1%

Upper West Branch Susquehanna River
381 Mgal/d

97%
3%

Lower West Branch Susquehanna River
49 Mgal/d

44%
42%
6%
3%
1%

Upper Central Susquehanna River
168 Mgal/d

39%
47%
10%
1%
1%

Amounts shown in millions of gallons per day. Mgal/d.
Population Projection

Upper/Middle Susquehanna Region Population Projection

Percent change in projected population from 2000 to 2030 by municipality

Gain
- greater than 100%
- 50 - 100%
- 20 - 50%
- 0 - 20%
- -20 - 0%
- less than -20%

Loss

City/Town
Major Roads
County Boundary
State Boundary
The largest river by discharge volume in the Upper/Middle Susquehanna Region is the Susquehanna River, which is also one of the largest rivers on the east coast of the United States. In fact, the Susquehanna River is the largest river lying entirely within the United States that drains into the Atlantic Ocean. The Susquehanna River flows from north to south beginning with its headwaters in New York, through Pennsylvania, and discharging into the Chesapeake Bay in Maryland.

A map showing the larger streams, lakes and wetlands within the Upper/Middle Susquehanna Region is provided on the next page. Streams and rivers can be classified according to their size based on a hierarchy of its tributaries. The hierarchy designates headwater streams as a first order stream. When two first order streams meet, the waterway becomes a second-order stream. When two second-order streams meet, the waterway becomes a third-order stream and so on. If a lower-order stream flows into a higher-order stream, the order designation does not change. For instance, if a first-order stream meets a second-order stream, the waterway designation remains second-order. For purposes of making the map readable, only higher order streams of the Upper/Middle Susquehanna Region are shown in the Surface Waters Map.

**Reynolds Spring Bog and Algerine Swamp Bog**

Reynolds Spring Bog and Algerine Swamp Bog, both located in Tioga State Forest approximately three miles south of Leetonia in Tioga County, are two of the finest examples of high mountain bogs in the Appalachian Mountain chain. The area’s glacial past contributes to the formation of the bogs, which were designated by the Department of the Interior and the National Park Service as National Natural Landmarks. Their ability to support geographically unique flora and fauna make them highly valued areas.

One interesting feature is the distinctly different vegetative species residing in the bogs. Algerine Swamp Bog, which is located just one-third mile southeast of Reynolds Spring Bog, contains plant species that are strikingly different than Reynolds Spring Bog. Both bogs have similar drainage and elevation, raising questions as to why there is such diversity, but also exemplifying the fact that bogs are completely unique micro-ecosystems.

**Streams**

The Susquehanna River and its West Branch are the major water bodies in the Upper/Middle Susquehanna Region. The major tributaries to the West Branch of the Susquehanna River in the region, listed from west to east are: Moshannon Creek, Sinnemahoning Creek, Kettle Creek, Bald Eagle Creek, Pine Creek and Loyalsock Creek. The tributaries to the Susquehanna River listed from north to south include Sugar Creek, Towanda Creek, Wyalusing Creek, Tunkhannock Creek, Lackawanna River and Fishing Creek.

These surface waters are part of the 23 subwatersheds in the Upper Susquehanna, Upper Central, Upper West Branch, Central West Branch and Lower West Branch subbasins, which together make up the Upper/Middle Susquehanna Region. The subwatersheds and subbasins can be located on the Upper/Middle Susquehanna Region Subwatershed Map in the Introduction Section of this region.

Approximately 55 U.S. Geological Survey (USGS) gaging stations that monitor peak stream flow conditions, water levels, discharge and water temperature are located in the Upper/Middle Susquehanna Region. Some gaging stations, including Towanda Creek near Monroe, Muncy Creek near Sonestown, and Young Womans Creek near Renovo also monitor water quality.

Surface waters in the Upper/Middle Susquehanna Region as well as all regions serve as a multiple-use resource. Not only do they provide a source of drinking water for many consumers, they also provide obvious recreational opportunities. The numerous high quality and exceptional value streams and creeks in the region are destinations to

**Water Resources**
Surface Waters

Upper/Middle Susquehanna Region Surface Waters

Scranton
Williamsport
Wilkes-Barre
State College
Hazleton
Bloomsburg
Milton
Lock Haven
Lewisburg
Clearfield
Carbondale
Bellefonte
Wellsboro
Tunkhannock
Towanda
Northumberland
Montrose
Galeton
Emporium
Danville

Streams (Perennial)
Water Planning Area Boundary
Lake, Pond or Reservoir
Wetlands
City/Town
Stream Gauges
State Boundary

0 5 10 15 20 Miles

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many who test their skills against the wild trout. Kayaking, rafting and tubing can also be enjoyed where the streams and rivers are large enough. These are only a sample of opportunities that surface waters, including ponds and lakes, can provide.

Lakes and Dams

Lakes are a prominent feature in the Upper/Middle Susquehanna Region, especially in the northwestern sections of the region. Numerous lakes throughout the region are created by dams; many of which have formed reservoirs for public water supply. Lake Scranton, the main surface water source of public water for the Scranton area, was formed by the construction of the Lake Scranton Dam. A treatment facility on the lake provides a maximum of 33 million gallons of water per day to the Scranton area.

Dams are also used to create recreational areas. One area of interest within the Upper/Middle Susquehanna Region includes Glendale Lake, formed by Glendale Dam in Prince Gallitzin State Park. Other lakes include Foster Sayers Reservoir created by Foster Sayers Dam on Bald Eagle Creek and Alvin R. Bush Dam located on Kettle Creek near Renovo. The impoundment on Kettle Creek provides a beach area and a boat launch.

Wetlands

Wetlands are areas where water covers the soil or remains at or near the surface for an extended period of the year. These habitats provide a hydrologic link between land and water resources (either surface water, groundwater or both). Wetland types differ according to characteristics such as topography, climate, hydrology, water chemistry and vegetation. The U.S. Fish and Wildlife Service provides information on the nation’s wetlands and deepwater habitats—including location, type and status—through the National Wetlands Inventory (NWI). There are two general categories of wetlands: coastal (including estuaries) and inland (including rivers, lakes and riparian areas). The NWI classifies inland waters according to the amount and type of vegetation present:

- Open water (rivers and lakes)
- Emergent/herbaceous (marshes, wet meadows and fens)
- Scrub-shrub (swamps and bogs)
- Forested (swamps and bogs)

Wetlands provide unique habitat to many species of plants and animals and also serve as natural filters to surface and groundwater supplies. Many wetlands in the region have the ability to eliminate contaminants such as nitrates and phosphorus as water flows through the wetland. The vegetation present in the wetland utilizes the excess waste, eliminating it from the water and reducing negative impacts to the environment. Wetlands also have the excellent ability to remove sediment from surface runoff. The vegetation plays a large role in reducing sediment as the sediment particles are captured and slowly removed as the water progresses through the wetland. These traits of wetlands have led some scientists to describe wetlands as “nature’s kidneys.”

As illustrated in the Upper/Middle Susquehanna Region Surface Waters Map, the northeastern portion of the region has a high concentration of wetlands. These wetlands, as described, provide a natural defense against harmful contaminants in water supplies. Many wetlands are located in densely populated areas and are pressured by development. Precaution should be taken to eliminate the destruction of these wetland areas. Allowing them to remain will protect our water sources and provide habitat for many plants and animals.

Special Protection Waters

Certain water bodies are designated special protection to prevent activities that could degrade water quality and therefore prevent these waters from meeting their uses. These special designations include federal or state Scenic/Recreational Rivers, High Quality and Exceptional Value Waters and Class A Wild Trout Waters.

Scenic Rivers

Scenic rivers in Pennsylvania are designated for their exceptional aesthetic, pastoral or recreational value and must be maintained for these values. There are more than 45 miles among two scenic rivers in the Upper/Middle Susquehanna Region. More detailed information about this program is included in the Statewide section of this atlas.

HQ and EV Waters

There are two types of special protection water classifications according to guidelines listed in Pennsylvania Code Title 25, Chapter 93 Water Quality...
Introduction, continued

Stream Releaf Program

DEP initiated the Stream Releaf Program in 1996 to restore streams and riparian areas in order to reduce and prevent stream bank erosion and sedimentation. The Stream Releaf Program has helped to create riparian buffers (vegetated areas along stream banks) along the North Branch of the Chillisquaque Creek in Lycoming County, White Creek in Susquehanna County, and Garman Run in Montour County. These are just a few of the more than 1,781 projects found in the Stream Releaf database for this region. For more information on this program, see “Stream Releaf” under DEP Programs at www.depweb.state.pa.us.

Acid Mine Drainage

The formation of AMD is primarily a function of the geology, hydrology and mining technology employed for the mine site. AMD is formed by a series of complex geochemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in coal, refuse or the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH raises to a level where precipitation occurs. Solubility charts for the various metals show the pH at which precipitation begins and the pH at which maximum insolubility occurs. Neutralization with limestone addition and bioremediation are some solutions to alleviate these symptoms but the problem still persists.

Wild Trout Waters

Approximately 271 waters in the Upper/Middle Susquehanna Region are designated by the Pennsylvania Fish and Boat Commission as Class A Wild Trout Waters. These waters support a population of naturally-produced trout of sufficient size and abundance to support a long-term and rewarding sport fishery. These streams are not stocked but are supported in full by the spawning of the wild trout populations, further illustrating their outstanding quality and protection they receive. Class A Trout Wild Trout Waters include wild brook trout fisheries, wild brown trout fisheries, mixed wild brook/brown fisheries and wild rainbow trout fisheries. Almost 65 percent of the Class A Wild Trout Waters are designated as HQ in this region. These HQ waters are designated based on the water chemistry and measurements of physical characteristics. There are also simple visual indicators one can look for to determine a stream’s general health. Impaired streams may have eroded or undercut banks, low water clarity, foul odors, large amounts of algae or have deep deposition of sediments that cover larger rocks on the bottom of the stream. All of these results help determine overall stream health. Restoring impaired streams requires plenty of time and effort combined with the most recent water quality evaluations available.

Impaired Waters

Stream health assessments are complex and time consuming efforts put forth by many individuals. Assessments can include individual studies on the living organisms and habitat within and around the stream, studies on water chemistry and measurements of physical characteristics. There are also simple visual indicators one can look for to determine a stream’s general health. Impaired streams may have eroded or undercut banks, low water clarity, foul odors, large amounts of algae or have deep deposition of sediments that cover larger rocks on the bottom of the stream. All of these results help determine overall stream health.

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The Pennsylvania Department of Environmental Protection (DEP), under Section 303(d) of the federal Clean Water Act, implements a program that assesses the water quality of state waters and identifies waterbodies that do not meet the standards for their designated uses. These designated uses—
including aquatic life, recreation and drinking water—are characterized by the in-stream levels of parameters (e.g., dissolved oxygen, pH, metals, siltation, etc). If a waterbody does not meet the standards for its designated use, it is identified as “impaired” on the Pennsylvania Integrated Water Quality Monitoring and Assessment Report. This report also identifies the cause of the impairment, which may be one or more point sources (like industrial or sewage discharges) or nonpoint sources (like abandoned mine discharge or agricultural runoff).

Once impaired waters and their reasons for impairment are established, the state determines what conditions are necessary to return the water to the quality that meets its designated use. DEP and the United States Environmental Protection Agency (EPA) work in conjunction with other organizations, such as Pennsylvania State University, to develop a Total Maximum Daily Load (TMDL) for each impaired waterbody. A TMDL defines the allowable pollutant loads a waterbody can receive from point and nonpoint sources and still be able to maintain its designated water quality standards.

The Impaired Waters Map on insertPage# shows the location of impaired streams and waterbodies in the Upper/Middle Susquehanna Region. Many of these streams are located in coal mining areas where acid mine drainage (AMD) has produced a negative effect on surface and groundwater resources.

Efforts to Address Impairment

Many impaired waters exist within the Upper/Middle Susquehanna Region. DEP supports local watershed groups, conservation districts and municipalities in developing Watershed Implementation Plans, which identify pollution sources in these areas and recommend best management practices (BMPs) for cleaning them up. These plans are submitted to the EPA to provide a “road map” for future stream restoration efforts and funding. Currently within the Upper/Middle Susquehanna Region, five Watershed Implementation Plans have been completed for Anderson Creek Watershed, Catawissa Creek Watershed, Hubler Run Watershed, Johnson Creek Watershed and Little Laurel Run Watershed. Specific examples of watershed cleanup projects in the Upper/Middle Susquehanna Region include:

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Acid mine drainage (AMD) is a leading source of water pollution in the Susquehanna Basin, especially in the West Branch of the Susquehanna River subbasins. When the Barnes and Tucker Lancashire 15 mine, located along the West Branch of the Susquehanna River, was closed in 1969, the dewatering pumps were shut off and the mine works were allowed to flood. Less than a year later, the mine pool rose to a level that caused a “breakout” of AMD, discharging millions of gallons of the pollutant into the waterway and killing aquatic life for 35 miles downstream. Under orders to remediate the pollution, the Barnes and Tucker Co. began pumping and treating the mine water, which lowered the mine pool levels to below discharge elevation, thus eliminating AMD. The treatment process resulted in the mine water diverted from the Susquehanna Basin to a facility in the Ohio Basin where once treated, it was discharged into Blacklick Creek (Ohio Basin). In 2001 the Barnes and Tucker treatment fund was exhausted and the company declared bankruptcy, leaving DEP to assume responsibility for continued treatment.

In 2006, SRBC announced plans to use grant money to build a treatment plant that would treat 10 million gallons of mine water per day from the Barnes and Tucker mine and release it into the West Branch of the Susquehanna River. This new facility would not only help improve the water quality of 25 miles of the polluted West Branch of the Susquehanna River, but it would also address 10 of the 15.7 million gallons per day needed to compensate for consumptive water use by farmers. The dual benefits of the proposed treatment facility make it a win-win measure for the West Branch of the Susquehanna Watershed.
In response to frequent flood problems in the Upper/Middle Susquehanna Region, reservoirs and dams have been created to help control floodwaters. Dams and reservoirs in the basin are managed and maintained by several government agencies like the Susquehanna River Basin Commission and the U.S. Army Corps of Engineers. Although numerous dams and reservoirs exist in the basin, occasionally heavy amounts of snowfall that melt during spring and are followed by heavy rains can overwhelm flood controls. This was the case in 1996 when the Upper/Middle Susquehanna Region experienced major flooding that damaged property.

Flood control utilizing dams and emergency reservoirs is now being augmented by improved stormwater management practices to prevent flooding. Flood mitigation measures are continually being refined by Pennsylvania and have helped reduce the overall impacts of major flood events. Since the Susquehanna River is one of the nation’s most flood prone regions, the Susquehanna River Basin Commission (SRBC) and other government agencies have developed the Susquehanna Flood Forecast and Warning System. This system utilizes state of the art technology that provides information to the National Weather Service for flood forecasting and issuing accurate flood warnings.

Flood hazards are also being addressed in Hazard Mitigation Plans that are being prepared by each county in the state. Also, the Pennsylvania Emergency Management Agency (PEMA) uses the Federal Emergency Management Agency’s (FEMA) hazard identification tool, HAZUS, to assist counties and local communities in assessing flood risks and preparing mitigation plans. More information can be gathered by visiting the PEMA Web site at www.pema.state.pa.us.

Local Flooding Occurrence

In response to frequent flood problems in the Upper/Middle Susquehanna Region, reservoirs and dams have been created to help control floodwaters. Dams and reservoirs in the basin are managed and maintained by several government agencies like the Susquehanna River Basin Commission and the U.S. Army Corps of Engineers. Although numerous dams and reservoirs exist in the basin, occasionally heavy amounts of snowfall that melt during spring and are followed by heavy rains can overwhelm flood controls. This was the case in 1996 when the Upper/Middle Susquehanna Region experienced major flooding that damaged property.
Bald Eagle Creek Watershed

Bald Eagle Creek Watershed is a 769-square mile drainage basin that includes most of central Centre County and the southern areas of Clinton County. A large majority of the watershed is agriculture within the fertile valleys. Other land uses include urbanized areas and abandoned mine areas. TMDLs have been developed for heavy metals associated with acid mine drainage (AMD), including aluminum, iron and manganese.

Nearly 1,237 miles of stream exist in the Bald Eagle Creek Watershed. More than 921 miles of those streams have been assessed, and approximately 15 percent have been found to be impaired. The majority of the impairment exists in the Beech Creek and Spring Creek areas of the watershed. In Beech Creek, more than 26 miles of its main stem and many more miles of tributaries are affected by AMD. Streams that flow through agricultural areas are more likely to exhibit impairment from sedimentation.

Studies are being performed by state and county agencies, conservancies, Penn State University and many others to continue monitoring, assessing and improving water quality in the Bald Eagle Creek Watershed. Development of the Spring Creek Watershed Commission and the Beech Creek Watershed Restoration and Preservation Association are just two examples of groups that were formed to continue restoration of the watershed and its tributaries. Best management practices presently implemented include restoration of abandoned mine sites near streams and wetlands monitoring and maintenance.

Did you know?

Lycoming County is the largest Pennsylvania county by area. At 1,235 square miles, the county is larger than Rhode Island (1,214 square miles).
Named for Civil War veteran Robert Ricketts, Ricketts Glen State Park is one of Pennsylvania’s geological masterpieces. Located in Luzerne, Sullivan and Columbia counties, the park is a popular site for many tourists. The Glens Natural Area is the main scenic attraction in the park, where the gorges of Ganoga Glen and Glen Lehigh unite at “Waters Meet” and flow down three waterfalls. The park is home to 21 beautiful waterfalls, which can be accessed from a variety of hiking trails. At 94 feet, the highest Ricketts waterfall is no Niagara, but is beautiful nonetheless.

Waterfalls are classified on how the water falls through its course, the volume of water flowing, the surface beneath and the geological process that created it. In the Glens Natural Area, there are two main types of waterfalls: bridal veil waterfalls and wedding cake waterfalls. Bridal veil waterfalls are generally over large rocks, where the falling water creates a thin layer that just barely covers the surface. On the other hand, wedding cake waterfalls cascade in a tiered fashion, and are often comprised of a series of waterfalls falling consecutively in close proximity. The water at Ricketts Glen generally falls over red shale and gray sandstone, and after thousands of years, has created aesthetically pleasing gorges and plunge pools into the rock. A unique feature at Adams Falls is the tub-like rock sculpture, created from the continuous grinding of rough sediment.

Lackawanna River Watershed

The Lackawanna River Watershed also has had TMDLs established for AMD, which include iron, manganese and aluminum. The watershed drains approximately 347 square miles and mainly resides in Lackawanna County but also includes portions of Luzerne, Susquehanna and Wayne counties.

Coal mining that began well over 200 years ago has adversely affected the Lackawanna River. Presently, there are numerous abandoned mining sites and coal refuse sites that contribute to the overall poor health of some tributaries within the watershed.

Although much damage has been done to the watershed, efforts are being implemented to restore the streams. The formation of the Lackawanna River Watershed 2000 Program was designed to provide a working relationship between state and local agencies to discuss and implement projects needed to restore the watershed. The Pennsylvania DEP, through its Abandoned Mine Reclamation Program, has also assisted in the repair of abandoned mine sites. Best Management Practices currently in use include restoration of abandoned mine sites near stream locations and relocating certain stream channels so as to direct them away from mine refuse piles.
Stormwater as a Resource

Stormwater runoff and flooding are natural events that have helped shape our watersheds and rivers. Human activities on the landscape routinely alter natural drainage patterns. Because of this, stormwater runoff is now being examined as to its effects on water quality, stream morphology, base flow and recharge. If not managed, these changes may increase localized flooding, stream bank erosion and loss of groundwater recharge. In addition to its physical impact on the environment, stormwater may carry a variety of pollutants.

By managing stormwater runoff as a resource rather than as a waste, a host of opportunities are available to protect the environment and complement water resource management. Since clean and abundant water is a vital resource, effective stormwater management provides for the protection and maintenance of the commonwealth’s essential water resources. Stormwater management affects and involves all of the possible avenues precipitation might follow after falling to the ground: runoff from the surface of the land; groundwater by infiltrating (or soaking) into the ground; evapotranspiration by evaporating directly into the atmosphere or by transpiring through plant processes and then evaporating; or stored water for various uses.

Human activities that result in land development or changes in land cover, or land use, often affect dramatically the quantity and quality of stormwater runoff from the land surface. These changes can produce harmful impacts on water resources, such as increases in damages from flooding; diminished stream flows and groundwater recharge; degradation of streams and stream channels from scour, erosion or deposition; and deterioration of water quality from pollution. These effects can be minimized, or avoided, through the careful preparation and implementation of comprehensive stormwater management plans and other planning or regulatory efforts.

Problems Associated with Stormwater and Flooding

Stormwater can have a detrimental effect on the agricultural lands, developed areas and the water quality of streams and rivers that flow through almost 18,300 square miles of land that makes up the Upper/Middle Susquehanna Region.

Flooding

Flooding is a localized temporary condition of partial or complete inundation of normally dry land from the overflow of streams or rivers. This potentially hazardous condition is generally the result of excessive precipitation. Generally, floods can be classified into two categories: flash floods, the product of heavy localized precipitation in a short time period over a given location; and general floods, caused by precipitation over a longer time period over the river basin.

Flash floods can occur within a few minutes or several hours of heavy amounts of rainfall, rapid snow melt or from a sudden release of water held back by an ice jam. Flash floods can damage buildings and bridges, uproot trees and scour new drainage channels. Although flash flooding often occurs along small rural streams, it is also common in urban areas.

The Susquehanna Basin is one of the nation’s most flood-prone areas. Of the 1,400 communities in the Susquehanna Basin, about 1,160 have residents located in flood-prone areas.

For more information on drought and flood protection, visit the Pennsylvania Department of Environmental Protection’s drought monitoring and flood information Web sites at: Drought Monitoring – www.depweb.state.pa.us/“DEP Programs–Drought Monitoring” Flood Information – www.depweb.state.pa.us/“DEP Programs–Flood Protection”
Urban and Suburban Runoff

As some areas of the Upper/Middle Susquehanna Region witness an expansion of development, stormwater runoff is being scrutinized along with its effects on water quality. Stormwater runoff from developed areas in Pennsylvania is the third leading cause of stream impairment. Pollution in the Upper/Middle Susquehanna Region can result from suburban development and impervious surface expansion resulting in potential runoff of petroleum products, nutrients, etc. The trend of population spreading out from towns and cities into areas that were previously rural is expected to continue into the future.

These population changes can result in development and an increase in impervious surfaces (surfaces that water cannot drain through such as concrete pavement, asphalt and roofing materials). As impervious surfaces increase so can the amount of pollutant-carrying stormwater from newly developed areas. Soils washed away from exposed building sites during construction also contribute to the excess sedimentation of streams.

Increased stormwater can cause sewer overflows in older towns that channel stormwater runoff to wastewater treatment facilities or worse yet, combined stormwater and wastewater can overflow into surface waters. Increased stormwater also destabilizes stream banks, disperses litter, distributes unnaturally warm water from developed surfaces into streams, and reduces groundwater recharge.

Agricultural Runoff

Water quality degradation and impairment in the Upper/Middle Susquehanna Region can also be caused by stormwater runoff from agricultural lands. As stormwater flows over agricultural lands, it can wash away excess nutrients like nitrogen and phosphorous from commercial fertilizers and manure. Soils from plowed fields and unstable stream banks, sometimes exposed in part by grazing animals, can also be washed away with stormwater runoff. Excess nutrients and sediments in this watershed not only impair Pennsylvania’s waters but also the Chesapeake Bay.

Karst Areas

Karst environments typically occur in areas where carbonate (limestone and dolomite) bedrock dominates the subsurface features. Natural breaks and fractures occur in carbonate bedrock which allow precipitation to infiltrate quite easily.

Water is a major reason for sinkhole collapses in Pennsylvania. Karst areas form over long periods of time as groundwater moves through breaks in the bedrock dissolving rock and creating caverns and spaces below the surface. The spaces may be filled with soil material or may be open. A sinkhole forms as material is flushed through underground spaces in the bedrock causing the surface to collapse. If more water is collected and redirected into a karst area this increases the potential for a sinkhole to occur.

Penn State University-Centre County Visitor Center

The Pennsylvania State University in State College and Centre County developed a visitor center on top of carbonate rock which has the characteristics of sinkholes and caves. The visitor center incorporates several stormwater infiltration techniques that imitate the natural hydrological systems that existed at the site before development. Creating similar hydrological conditions was important because land that is altered can concentrate stormwater into areas that accelerate the formation of sinkholes.

Development of the site required excavating the existing soil and limiting infiltration from its natural levels. It was recognized that any allocation of stormwater from one portion of the site to another would require stormwater pipes to traverse bedrock. Stormwater pipes crossing bedrock would require excavation and could lead to the formation of sinkholes.

In order to avoid using stormwater pipe systems, the visitor center employed stormwater best management practices such as porous asphalt parking lots, porous concrete sidewalks, subsurface infiltration trenches, vegetated infiltration bed and several rain gardens/bioretention areas.
Stormwater and Flooding, continued

Penn State University-Centre County Visitor Center

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Floodplain Development

Development in floodplains is a highly regulated process that is guided by many ordinances and regulations. Two state laws assist with the responsibility of regulating flood plain development: The Pennsylvania Flood Plain Management Act of 1978 (Act 166) and the Pennsylvania Municipalities Planning Code.

Since floodplains are natural flood controls, altering them only slightly can have negative affects. Construction in floodplains can increase storm runoff, sedimentation and subsequent stream bank erosion resulting from the increase in storm runoff. Their important contributions during a flood event help protect the surrounding land area. They allow excess water to be absorbed, help reduce erosion and provide habitat for plants and animals. It is because of these, and many other benefits, that they are closely regulated and protected from destruction.

Agricultural Runoff Best Management Practice: No Till Farming

A farming practice introduced in the 1980s is growing in popularity with environmentally savvy farmers. No-till farming cuts down on the amount of fertilizer and soil washed away in rainstorms and also reduces carbon dioxide released into the atmosphere by eliminating the entire plowing system, commonly used by farmers.

Traditionally farmers solely used plowing to ready the fields for planting crops. Plowing, or tilling, turns over the top layer of soil. This practice eliminates most weeds and allows for fertilizers and pesticides to penetrate the ground. Also, plowing helps to rid fields of decayed crops and other organic matter.

However, tilling exposes topsoil making it susceptible to the effects of stormwater erosion. Over time, plowed fields lose measurable amounts of topsoil. In addition to the soil itself, fertilizers and pesticides are carried by stormwater to nearby creeks and streams, polluting those streams and adding to the pollution of larger waterways downstream.

Instituting no-till farming is a simple solution to potential environmental challenges. No-till farming does not use plows, and seeds are instead planted in undisturbed soil. The carbon-containing organic matter that provides nutrients to plants stays in the top layers of soil where it slowly decays, fertilizing the crops and protecting the soil from erosion. No-till farm equipment create slots where seeds are planted, disturbing less than 30 percent of the total soil surface.

Farmers have accepted the benefits of no-till farming and have instituted the practice in their own fields. Along with the environmental benefits, local farmers have reported the benefits of the retained, rather than eroding, soil. These farmers have noticed a significant increase in their harvest, yielding higher profits. Fuel and fertilizer costs associated with plowing practices are reduced with no-till farming, also making the crop more profitable.

Overall, no-till farming is one of the top cost effective best management practices that help to improve environmental conditions. With increased awareness, more farms can institute the practice to not only help reduce water pollution, but increase personal gain from potentially larger harvests.

Increased urban and suburban development. Urban and suburban development can alter the land’s natural state and ability to absorb precipitation, concentrate stormwater runoff and accelerate the formation of sinkholes in this area.

In the Bald Eagle Creek Watershed and other parts of the Upper/Middle Susquehanna Region, stormwater from agricultural land contributes to impairment of surface water and groundwater. Some agricultural practices have allowed for stormwater to disperse pathogens, nutrients, herbicides, pesticides and sediment into streams.

The West Branch of the Susquehanna River has been impacted by stormwater runoff from agricultural, urban and suburban lands. In the lower section of the West Branch, stormwater runoff from agricultural lands account for approximately 70 percent of stream impairment. The West Branch also accounts for more than 29 million pounds of combined nitrogen and phosphorus found in local waters, some of which is due to stormwater runoff.
A large portion of the Upper/Middle Susquehanna Region is located in the Appalachian Plateaus physiographic province, while the remainder of the region is found in the Ridge and Valley physiographic province. A discussion of these provinces and their origins is provided in the Statewide Overview Section and can be located on the map shown in that section.

A significant factor in the Upper/Middle Susquehanna Region’s geology and groundwater was the presence of glaciers approximately 20,000 years ago. Another recognizable trait of the region occurs where the Ridge and Valley province transitions into the Appalachian Plateau. The change in topography can affect groundwater in many ways and also control the presence of mineral (both fuel and non-fuel) resources.

The connection between surface water and the aquifers that store and discharge groundwater is often misunderstood. The water table, which is the boundary below which all the spaces and cracks in the soil and bedrock are completely saturated, is often times a reflection of the surface topography. As the topography changes due to hills, mountains or valleys, the water table’s elevation and depth will often times change with it reflecting the changes occurring at the surface.

However, streams, wetlands, springs or rivers will often form in areas where the water table intersects the land surface. These features form where the groundwater discharges from groundwater storage and becomes surface water. This discharge of groundwater into surface water is also known as base flow. Base flow can be thought of as the sustained low flow of a stream because it is supplied by the groundwater that is discharging from underground storage. Dry streambeds or springs that no longer supply water are a result of the water table being lower than the land surface.

**Bedrock Geology**

As illustrated by the Bedrock Geology Map on the next page, the sandstone, shale and carbonate formations in the Upper/Middle Susquehanna Region are consolidated rocks that comprise the majority of aquifers in the region. Groundwater is contained within and moves through fractures, spaces and partings in the consolidated rock. Aquifers exist here under two different conditions. Where water only partly fills the aquifer and is free to rise and fall, it is referred to as an unconfined aquifer or water table aquifer. Where water completely fills a rock unit and the aquifer is under a low-permeable feature or confining layer, this aquifer is said to be confined. This confining layer helps protect this kind of aquifer from contaminated water migrating from above. Another key difference between the two is the varying pressure regimes. The unconfined aquifers are under atmospheric pressure while confined aquifers are at a greater pressure due to the confining layer overhead.

The carbonate bedrock formations in the Upper/Middle Susquehanna Region are comprised of limestone and dolomite. Limestone bedrock formations in the region are prone to chemical dissolution, or dissolving, and form a landscape called “karst.” These voids may be filled with water, soil materials or air. Interconnected pathways can exist through the rock to allow water to be quickly transported in high volumes. If a contaminant reaches the void spaces, it easily enters the groundwater and can be transported extensive distances to other water supply or discharge areas. The creation of these interconnected voids in limestone bedrock can produce sinkholes, closed depressions and disappearing streams; common features of a karst environment. For more information on karst environments, see the Lower Susquehanna Region Geology and Groundwater Section.

**Appalachian Plateaus Province**

The largest land area of the Upper/Middle Susquehanna Region is found within the Appalachian Plateaus Province. The bedrock formations are largely derived from sedimentation that occurred nearly 400 million years ago. The sedimentation occurred while the province was covered by saltwater and freshwater seas that once occupied the area. Bogs and swamps developed when the area was not submerged which resulted in large beds of peat, an accumulation of decaying organic matter. Sedimentation occurred again through the area’s history, covering the peat beds. The weight and pressure caused by the new sediment increased over thousands of years and eventually caused the peat beds to metamorphose into coal.

Within the province, topography generally reflects the underlying bedrock. The gently folded and warped bedrock was modified by streams that scoured valleys into the surface. Abrupt changes in elevation and...
Geology and Groundwater, continued

topography often occur where provinces transition and encounter different bedrock. Typically, these transitions are along areas of bedrock that are more erosion resistant and form a distinct change in elevation, or an escarpment.

The northern and northwestern areas of the Upper/Middle Susquehanna Region were glaciated several times in their past. Counties in the region that experienced the most recent glaciation include Potter, Tioga, Lycoming, Bradford, Sullivan, Columbia, Susquehanna, Wyoming, Luzerne, Wayne and Lackawanna counties.

The glaciers deposited large amounts of unconsolidated material, or till, as they receded. Bogs and swamps are common in these areas, forming in the depressions created by the glaciers. Also, a fragipan layer can develop in the till, retaining water on the surface as it slowly infiltrates into the groundwater supplies. A fragipan layer is a very dense layer of soil forming beneath the surface that inhibits infiltration of water.

As the Bedrock Geology Map illustrates, the sandstones and more resistant bedrock types typically formed the highland areas across the entire province. Valley areas are commonly found in the less-resistant shale, carbonate and other sedimentary rock. These valley areas are also the discharge areas from the recharge that occurs in the upland areas. The downward flow of water through the ground caused by gravity and the pressure from the water above will cause water to discharge into streams and creeks or as springs in the valleys and low lying areas.

Thick areas of glacial till also aid in groundwater recharge if permeability is sufficient. Till can act as a sponge absorbing precipitation and slowly releasing it into the aquifers, increasing groundwater supplies. However, areas with a fragipan layer are less likely to receive large amounts of infiltrated precipitation.

Ridge and Valley Province

The Ridge and Valley Province, as shown in the map on insertPage makes up the southern areas of the Upper/Middle Susquehanna Region which include the State College, Lock Haven, Lewisburg and Bloomsburg areas. Long and narrow mountain ranges are common in this area.

Bedrock in the Ridge and Valley Province, as shown in the map on the previous page, was also formed by sedimentation from ancient saltwater and freshwater seas that covered the province, much like the Appalachian Plateaus Province. However, the ridges and mountains were formed from past geologic events when the continents collided with each other, forcing the bedrock upward and creating the Allegheny Mountains. The formation of the mountain chain was completed approximately 250 million years ago.

Did you know?

Flagstone mined from quarries near Sinnemahoning in Cameron County was used to build the facade at the Tomb of the Unknown Soldier in Washington, D.C.

Susquehanna County is the largest producer of Pennsylvania Bluestone in the state. Pennsylvania Bluestone is a prized dimension stone that is named for its typical blue color.

Pennsylvania Bluestone formed after ancient seas that once occupied the area receded more than 400 million years ago. The sediment that resulted from the seas eventually solidified and transformed into the rock that is present today. Bluestone formed in the coastal regions of the ancient seas where fast, shallow moving waters deposited their sediments. The noticeable blue color of the sandstone resulted from minerals being carried by groundwater through the rock formations.

The bluestone is valued for several of its natural properties. It is easily separated into sheets of desired size and can be cut to nearly any dimension. The stone is weather resistant and will stand up to any weather condition with relative ease. Pennsylvania Bluestone is also appealing because of its flexibility to conform to contemporary or traditional building design.

The bluestone’s strength and durability is exemplified by its use in the Starrucca Viaduct in Lanesboro, Susquehanna County. The viaduct, completed in 1848, is the oldest and one of the longest railroad bridges of its kind in Pennsylvania. The use of Pennsylvania Bluestone in the construction of the viaduct is a tribute to the region’s access to a truly unique and durable building material.
Geology and Groundwater, continued

As the mountains eroded, resistant sandstones remained forming the ridges and mountains we see today. The valley areas consist of shale, carbonate, siltstone and other sedimentary bedrock formations. These valley areas, like those in the Appalachian Plateaus Province, are most likely to have the greatest groundwater recharge. Carbonate bedrock, or karst, aquifers in the valley areas provide some of the largest groundwater discharges. Karst features are shown on the map on the next page. The State College area in Centre County, in fact, is supplied by one of the largest regional karst aquifers in the commonwealth. The sandstone aquifers in the region are dependent on fractures for infiltration and transportation of groundwater.

Like glacial till in the glaciated regions, thick soils that formed from the erosion of the softer shale and carbonate bedrock absorb large amounts of water and gradually release it into the aquifers. Thick areas of soil and sediment typically occur in the valley areas, further increasing their groundwater recharge capabilities.

Also located in the Ridge and Valley Province is the Anthracite Valley Section, also known as the Northern Anthracite Field. Fractures within the coal bed can provide conduits for groundwater transportation, but groundwater resources in these areas are often degraded as they come in contact with coal-bearing rock.

Mineral Resources

Mineral production within the Upper/Middle Susquehanna Region exists in several areas. Lime and crushed aggregate production occurs in areas located within the Ridge and Valley Province where limestone and carbonate rock are prevalent.

Sand and gravel production occurs in the glaciated regions of Wyoming, Luzerne, Bradford and Lycoming counties. Susquehanna County also contains...
one of the largest concentrations of Pennsylvania Bluestone, which is unique sandstone that derives its name from its typical blue color. Pennsylvania Bluestone is a form of dimension stone that can be cut and shaped into many different sizes.

Natural Gas Resources
Natural gas fields exist in the western areas of the region around Indiana, Clearfield, Elk, Cameron, Centre and Clinton counties. Natural gas was initially thought to be a waste product of the early oil drilling operations throughout Pennsylvania. Most discoveries in the past were by accident and only a handful of entrepreneurs were able to utilize the fuel efficiently. Presently, there are numerous natural gas extraction operations within Pennsylvania and the Upper/Middle Susquehanna Region, including sites in Indiana, Clearfield, Cambria and Elk counties.

Underground natural gas storage is a practice that occurs in the Upper/Middle Susquehanna Region. For the most part, natural gas demand is determined with the fluctuations in weather. Weather can be difficult to predict, making gas demand difficult to predict as well. The utilization of underground storage provides reservoirs within a relatively close distance to consumers instead of having to transport the gas for hundreds or thousands of miles across other states. Tioga, Potter and Clinton counties contain many of the underground storage...
areas in the Upper/Middle Susquehanna Region as well as the state. The gas is pumped into depleted natural gas reservoirs from past operations. Since they originally contained natural gas, operators have little concern about the gas escaping because of the presence of natural confining layers surrounding the reservoir. Pennsylvania contains more underground storage facilities (49) than any other state in the U.S.

**Natural Gas—Environmental Concern**

As with any resource extraction that occurs, effects to the environment and corresponding protection strategies are developed. The same applies with natural gas extraction and the waste that is produced.

A common waste product that is associated with the extraction of natural gas is brine. Brine is a saline solution that accompanies the oil and gas in the bedrock. As the gas or oil is extracted, various amounts of brine are also brought to the surface where it is separated from the gas or oil and stored in large lined pits or storage tanks. If storage areas fail, surface water and groundwater sources can become contaminated by the salty, degraded brine solution.

Environmental issues also arise as natural gas wells no longer provide an economic gain to the owner or client and are abandoned. Plugging of these abandoned wells is necessary to eliminate any threat to water supplies and the surrounding environment. Act 78 of 1992, which amended Pennsylvania’s Oil and Gas Act, helps fund money for “orphan wells” to be plugged to reduce harmful environmental impact. Wells are designated as orphan wells if they were abandoned prior to April 18, 1985.

**Coal Resources**

Both forms of coal, anthracite and bituminous, are common in the Upper/Middle Susquehanna Region. As shown on the coal fields map on this next page, anthracite coal fields exist in the eastern areas of the region while bituminous coal exists in the west.

Anthracite coal has been mined for over 200 years in Pennsylvania. The Northern Anthracite Field, stretching from Columbia County northwestward through Luzerne, Lackawanna, Wayne and Susquehanna counties has been a large contributor to overall anthracite production. In the past, manmade canals allowed mined anthracite coal to be transported out of the region to inland cities via rivers. Railroads further increased the transportation routes and eventually dominated transportation within the coal market.

Bituminous coal mining’s history also originates over 200 years ago, with the first discovery near Pittsburgh. However, large deposits were soon discovered in Clearfield, Cambria and Centre counties within the Upper/Middle Susquehanna Region.

A large majority of bituminous coal is mined using the room and pillar method. This method involves mining large open areas into the coal seam (rooms) while leaving large columns (pillars) to support the overburden above.

**Coal—Environmental Concerns**

Both forms of coal mining can potentially impact local water supplies. The open pit mines and large piles of mine waste common with anthracite mining can lead to acid mine drainage (AMD).

AMD is the result of mine spoils and waste rock containing sulfur minerals being exposed to air and water. A chemical reaction occurs that releases metal ions into the water which increases the acidity of the water. The contaminated water then infiltrates fresh water supplies and creates problems that are difficult to remediate. Some solutions, such as neutralization with limestone and bioremediation, have alleviated these symptoms, but the problem still persists.

Mitigating for AMD-contaminated water supplies can be accomplished by the installation of man-made wetlands. In addition to their natural water purifying abilities, wetlands can be utilized to reduce the affects of AMD. Wetlands are commonly used because they tend to retain water for much longer periods of time than that of other surface waters, like streams or creeks. AMD wetlands, or passive mine drainage treatment systems, as they are commonly referred, can be constructed to include berms and beds that consist of carbonate-based rock that will act as a buffer and neutralize the acidity, directing the harmful drainage through a series of carbonate-based rock filters, or installing PVC covers over the rock to eliminate surface runoff and contamination.

Nearly identical to acid mine drainage, acid-producing rock results from exposing rocks containing iron-sulfide minerals to air and water. Specifically and in most cases, the exposure of the mineral pyrite to air and water will likely result in acid-producing rock. As the rock is repeatedly exposed to wet and dry conditions that vary with the weather, oxidation occurs and ferrous and ferric iron will be created. This process occurs continuously and vast quantities of these excess metals will create acidic conditions with a pH commonly ranging from 2 to 4. Some extreme cases have produced values as high as 8 (basic) to 5 (acidic). These reactions will undoubtedly harm local water resources if remediation is not applied.

The exposure of acid-producing rock is a concern in areas of development, such as new highways or housing developments, where the rock is known to exist. Common remediation for acid-producing rock can include anaerobic wetlands designed to act as a buffer to reduce the acidity, directing the harmful drainage through a series of carbonate-based rock filters, or installing PVC covers over the rock to eliminate surface runoff and contamination.

[Image of wetland and stream]
acidic water. Also, by increasing the retention time of the water in the wetland before it is released will allow heavy metals, such as iron, to precipitate and settle out, further increasing the quality of the water.

For more information on passive mine drainage treatment, reference the Sugar Creek Mine Reclamation Project located in the Ohio Region Geology and Groundwater section.

Room and pillar mining, which also occurs in the region, has the ability to greatly alter groundwater flow. If mining occurs below the water table, the low pressure area created by the mine encourages groundwater to move downward, away from the surface. Draining of overhead aquifers in this case is also referred to as “dewatering.” This change in flow can alter surface water baseflows by decreasing flow rates or eliminating streamflow all together.

On January 22, 1959, a devastating mining accident wrecked Port Griffith, Lackawanna County, forever changing the anthracite industry of northeastern Pennsylvania.

Owned by the Knox Coal Co., the River Slope Mine was comprised of various chambers that were illegally dug under the Susquehanna River, two of which extended past the officially designated “Stop Lines.” Moreover, the chambers were quarried without the benefit of boreholes to determine the thickness of the rock cover (35 feet was considered the minimum) and without proper surveying. Miners obeyed company orders and quarried the two tunnels, following their coal at a sharp upward angle toward the riverbed until the rock cover dwindled to a mere six feet. The thin “roof” could not withstand the weight of the Susquehanna River and collapsed into the chamber below.

Railcars were used to plug the whirlpool formed by the water draining to the mine. It took nearly three days to partially plug the mine. Twelve miners died and were never recovered. One miner, Amadeo Pancetti, was awarded the Carnegie Medal for leading 32 of the 69 survivors to safety.

It has been estimated that more than 10 billion gallons of water filled the mines. The disaster completely ruined much of the anthracite industry in the region, as the two largest coal companies—the Pennsylvania and the Lehigh Valley—shut down their mines due to permanent water damage. Approximately 7,500 jobs were lost.

Responsible for the disaster, the Knox Coal Co. was found to have been involved in organized crime. Many people involved with the mining company were indicted for criminal activities and three men served jail time.
History of the Upper/Middle Susquehanna Region

Studying the change in land use over time can offer insight into the development patterns that may influence the future landscape of an area.

Pennsylvania's Forests

Pennsylvania's water resources are closely tied to its forests. The vast forests of Penn's Woods provided clean, pure water not only for Native Americans, but also for the state's founder, by acting as a natural filter. However, William Penn might not recognize his property today.

When colonists first arrived in the mid-Atlantic, more than 90 percent of the landscape was forested. By the mid-1800s, most of the region’s trees had been cut down to clear land for cities, towns and farms or to provide lumber. Once dominated by virgin pine hemlock and chestnut forests, the forests regenerated into current day second-growth mixed deciduous and evergreen forests.

The post-colonial changes to the forest were significant. At one time, the predominant tree species in the mid-Atlantic deciduous forest was the American chestnut. Unfortunately, with the accidental introduction of a fungus (Endothia parasitica) to the area in 1904, most American chestnut fell to this disease. The fungus survives in stumps and saplings affecting any trees approaching maturity. The great oak-chestnut forests of the mid-Atlantic have been replaced by an oak-hickory mix.

Early Settlement

Although the Iroquois claimed ownership of most of Pennsylvania, few Native Americans settled in the Upper Susquehanna Region. The Tuscarora Native Americans, a branch related to the Iroquois, had emigrated from North Carolina and settled near Lanesboro, and there were some villages in Harmony, Oakland and Great Bend. There were also some Delaware Native American villages in Bradford County and other areas as well. Due to the pressures of European settlement, in 1742 most of the Delawares, under their chief Tadame, came to the Wyoming Valley and built a village on the flats below the present site of Wilkes-Barre.

During the Revolutionary War, British troops and their Native American allies entered the region. The famous Battle of Wyoming took place on July 3, 1778. A much smaller American force met the British and the Native Americans on the open field of battle. The Americans were severely beaten. On July 4, 1778, British Major John Butler demanded
the surrender of all forts. During the next summer American forces under the command of General John Sullivan returned to the Wyoming Valley and the upper Susquehanna River area and destroyed forty native villages. General Sullivan’s actions essentially marked the end of the Native American populations in the upper regions of the Susquehanna River.

The majority of the land within the Upper/Middle Susquehanna Region was claimed by both Pennsylvania and Connecticut prior to 1782. Connecticut organized the Susquehanna Co. and claimed that the Charter from Charles II of England included this land in 1662. Pennsylvania also claimed the land under a Charter dating to 1681. They called the area the Wyoming Valley. The area near present Wilkes-Barre, was settled by both Pennsylvania and Connecticut colonists which resulted in the Pennamite-Yankee wars. A decree issued at Trenton in 1782 decided the matter in favor of Pennsylvania and opened the land up for settlement. The western half of this region was opened up for settlement by a purchase from the Native Americans in 1784.

The Susquehanna River was used to a great extent for transportation. From the earliest times boats were used for the transportation of goods and produce up and down the river, and many of the first settlers traveled to their new homes by boat. Grain and manufactured goods were sent downriver in keel-boat. Although steamboat transportation was tried in 1826 by Peter Karthaus of Clearfield County, his boat, the Codorus, proved to be impractical during its trip to Williamsport, ending any substantial investment in steam transportation on the north Susquehanna River.

Anthracite
The southeastern portion of the Upper/Middle Susquehanna Region lies in the large crescent-shaped anthracite coal fields known as the Wyoming and Northern Coal Fields. During the War of 1812, coal obtained from Britain was scarce, forcing Americans to find their own sources of energy. A number of small anthracite coal companies were started in Luzerne County at this time to meet the demand for domestically produced anthracite.

Early transportation in northeastern Pennsylvania consisted largely of privately owned and maintained turnpikes. These turnpikes connected towns and settlements located along the more frequently traveled routes and were not well suited for the transport of large quantities of material. In the early 1800s, a canal and railroad system was developed along the Susquehanna River to transport large quantities of domestically produced anthracite.

Anthracite coal from northeastern Pennsylvania first came from the southern and western mine coal fields via the Schuylkill Canal, which opened in 1825. The northern coal field, running through the Wyoming Valley and Luzerne County, was made more accessible with the opening of the North Branch Canal, which opened in stages from 1830 to 1834. Most of the anthracite headed south to Baltimore and Philadelphia on local and regional canals. With the completion of the North Branch Extension Canal from Pittston to New York State in 1858, the coal also traveled to New York State and New England.

The first railroad in Luzerne County was the Mauch Chunk Railroad. Built in 1827, it connected the coal mines of Wilkes-Barre with the Lehigh River. Over the next 50 years at least 10 more rail lines were constructed in Luzerne County. In the late 1800s and early 1900s, hundreds of thousands of immigrants, many from eastern European countries, flocked to the region to work the anthracite coal mines. This transformed the Wyoming Valley from an isolated farming area into a metropolis.

Did you know?
Moshannon Creek’s name was translated as “Moose Stream” from a Native American dialect indicating that it was probably one of the few areas in the state that moose inhabited before European settlement. Since then, the waterway has earned the nickname “Red Mo” due to the staining of rocks from acid mine drainage.
By 1900, a wet process was used to separate coal from impurities. Coal was put into large metal cylinders in which water was circulated. The centrifugal force of circulating water separated the coal and culm, or waste. Mining activities, mine drainage, and the wet process polluted billions of gallons of water on a daily basis across the anthracite region from the early to mid-20th century.

The anthracite industry began to decline in the second quarter of the 20th century largely as a result of the use of bituminous coal from western Pennsylvania and West Virginia. As the stock market crashed in 1929, the coal industry struggled and it never fully recovered. By the 1920s consumers gradually began to switch from coal to oil, gas and electricity. Mine operators moved on to other enterprises, leaving the area with an unemployment rate in excess of 12 percent after World War II.

Surface mining increased in the mid-20th century. Surface mines often disrupted the flow of tributary streams. Many water courses were diverted around the workings or run through flumes. Abandoned water courses disrupted the flow of tributary streams. Many water courses were diverted around the workings or run through flumes. Abandoned water courses and flumes would fail and stream flow would enter and infiltrate into the underground workings.

Lumber
Williamsport, Lycoming County, owes its existence largely to the lumber industry. Milling began as early as 1792, but the lumber industry quickly grew to massive proportions. Sawmills and furniture factories were among the most prosperous industries. Woodworking factories produced billions of board feet of lumber and wood products during a logging boom after the Civil War. The industry was so prosperous that the city once boasted more millionaires per capita than any other American city. The industry gradually declined in the 1890s when the surrounding hills were finally stripped of saleable lumber and the logging crews moved west. Today, the entire area is reforested with mostly second-growth timber, providing scenic beauty and woodland recreational opportunities.

Early Iron Industry
The Montour Iron Co., located in Danville, was one of many success stories of the early iron industry in the commonwealth. Established in 1845, Danville’s location near large fields of anthracite coal, iron ore and limestone gave it an unparalleled advantage in the iron business. William Hancock, a businessman originally associated with Britain’s iron industry, along with his partners, had created a process that produced “rolled” iron in the shape of a “T” in mass quantities. By 1852, it is estimated that nearly 136,500 tons of iron were rolled in mills that surrounded the Susquehanna River.

Upper/Middle Susquehanna River Basin Water Use

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>77%</td>
</tr>
<tr>
<td>Pasture/Grass</td>
<td>10%</td>
</tr>
<tr>
<td>Row Crops</td>
<td>6%</td>
</tr>
<tr>
<td>Institutional/Industrial/Transportation</td>
<td>2%</td>
</tr>
<tr>
<td>Residential</td>
<td>2%</td>
</tr>
<tr>
<td>Active Mines/Mined Areas</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Bare</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>1%</td>
</tr>
<tr>
<td>Water</td>
<td>1%</td>
</tr>
</tbody>
</table>

Land Use in the Upper/Middle Susquehanna Region Today

As the pie chart indicates, 77 percent of the region’s land area consists of forestlands. Deciduous species make up the majority of the forest types throughout the region and accounts for half of the entire regional land use. Pasture and hay are a substantial part of the agricultural sector. Developed areas are concentrated in the southern and southeastern portion of the region, sweeping from Scranton/Wilkes-Barre to State College.

The Land Cover Map on the following page shows the various land uses and vegetative cover across the Upper/Middle Susquehanna Region. Definitions for the land use categories used in the Land Cover Map are as follows:

Development
Only four percent of the land in the Upper/Middle Susquehanna Region is developed for residential, commercial and industrial use. Developed areas are categorized by the by the amount of land area covered by impervious surfaces:

- Developed, Open Space – less than 20 percent of the area is covered by impervious surfaces, mostly vegetation in the form of lawn grasses (e.g., golf courses, parks, single-family housing units and vegetation planted in developed settings for recreation, erosion control or aesthetic purposes)
- Developed, Low Intensity – 20 to 49 percent of the area is covered by impervious surfaces (e.g., single-family housing units)
- Developed, Medium Intensity – 50 to 79 percent of the area is covered by impervious surfaces (e.g., apartment complexes, row houses and commercial/industrial areas)
- Developed, High Intensity – 80 to 100 percent of the area is covered by impervious surfaces, where people live and work in high numbers (e.g., apartment complexes, row houses and commercial/industrial areas)

Forest
A majority of the land in the Upper/Middle Susquehanna Region, 77 percent, is covered by forests. Forest lands are categorized by the type of trees that dominate the area:

- Deciduous Forest – greater than 20 percent of the area is dominated by trees that are taller than 5 meters and shed leaves in the autumn
- Evergreen Forest – greater than 20 percent of the area is dominated by trees
taller than 5 meters and maintain their leaves all year round

- Mixed Forest – greater than 20 percent of the area is dominated by trees taller than 5 meters but are not dominated by deciduous or evergreen species

**Agriculture**
Approximately 16 percent of the land in the Upper/Middle Susquehanna Region is used for farming. Agricultural lands are categorized by the type of crop that is cultivated:

- Pasture/Hay – greater than 20 percent of the area is covered by grasses and legumes planted for livestock grazing or hay production
- Cultivated Crops – greater than 20 percent of the area is covered by annual crops (e.g., soybeans, vegetables, tobacco, cotton), orchards and vineyards and/or all land that is actively being tilled

**Other**
Less than four percent of the land in the Upper/Middle Susquehanna Region is covered by barren lands, open water, wetlands, shrub/scrub and grassland/herbaceous areas. These areas are categorized by the amount of land covered by vegetation (other than trees) and/or by water:

- Barren Land (Rock/Sand/Clay) – Areas of accumulated earthen material (e.g., bedrock, sand, glacial debris, strip mines, gravel pits) with less than 15 percent vegetation cover
- Open Water – all areas of open water with less than 25 percent of the area covered by vegetation or soil
- Wetlands – areas where the soil is periodically saturated or covered with water and greater than 20 percent of the area is covered with vegetation

**How Land Use Affects Water Resources**
The various uses of land affect water in different ways, some better than others.

**Importance of Forested Areas to Water Supplies**
The Upper/Middle Susquehanna Region has more forest cover than any other Pennsylvania region. The region is comprised of the Central Appalachian Ridge and Valley region. This mid-Atlantic region supports hardwood forests including pine-oak and oak-hickory forests, as well as coniferous forests, including eastern hemlock (Tsuga canadensis). The region consists of 77 percent forested areas. Deciduous forest types dominate the landscape, with 50 percent of the total land area. Mixed and coniferous forests comprise 27 percent of the basin.

Forested areas are critical to the supply and quality of water resources. Tree canopies and the rich organic matter found in forest floors store, clean and slowly release the majority of water that replenishes groundwater and maintains streamflow. Remote areas of forested lands are reserves of clean groundwater, and are often good locations for municipalities to drill high-yield water wells.

Some forests are particularly effective at delivering water quality benefits. Wooded buffers along streams trap sediment and transform nutrients and other pollutants...
into less harmful forms. For example, properly managed woodlands can remove 90 percent of the nitrates in stormwater runoff given the right soil conditions.

With regard to drinking water, intact forests within wellhead protection areas play a vital role in protecting the amount and quality of water reaching public wells. In developed areas, urban forests are critical to reducing stormwater runoff from small storms.

Forests also protect local waterways by retaining nitrogen in air deposition. An oak/hickory forest retains an average of 90 percent of atmospheric deposition, while a spruce/fir forest retains 78 percent. In general, coniferous forests use less nitrogen than deciduous forests (a factor more of the soils than the tree itself). The exception is the Eastern hemlock forest, which is highly efficient at retaining nitrogen. Forests also sequester or remove carbon from the air helping to reduce the impact of carbon dioxide on global warming.

Some of the most important forests for water resource protection are the most threatened. Forests are vulnerable to development and other land uses that can fragment high quality forests and expose woodlands to invasive species. Parcelization is another threat—more people own forests than ever before but many own less than 10 acres. As larger tracts of forest land are subdivided, it is important that woodlot owners be educated about sustainable forest management practices.

In addition, efforts to protect woodlands can be misguided and serve to diminish forest health. Under the Municipalities Planning Code, forestry, which includes timber harvesting, is a permitted use by right in all zoning districts. Concerns over forest regeneration and wildlife habitat have led to the adoption of local timber harvesting ordinances that are, in some cases, overly restrictive in prescribing timber harvesting practices. Local governments can benefit from knowledge of state regulations protecting against poor timber harvesting practices and advice from a professional forester when planning and adopting local ordinances.

Timbering
Within the Upper/Middle Susquehanna Region, eight counties contain forested land that is part of the Lumber Heritage Region: Potter, Tioga, Lycoming, Clinton, Centre, Elk, Cameron and Clearfield counties. The Lumber Heritage Region was created in 2001 as one of 12 Pennsylvania Heritage Areas to “implement the historic preservation and cultural conservation” of these areas.

Timbering in the region and Pennsylvania has economic benefits as well as ecological benefits. Economically, Pennsylvania is the nation’s largest producer of hardwood lumber, producing more than 1 billion board feet per year. The vast forested area of the Upper/Middle Susquehanna Region contributes largely to this sum. Ecologically, timbering provides habitat diversity and mimics natural disturbances that sustain forests.

Timbering companies work hand in hand with agencies such as DEP, DCNR, EPA, U.S. Army Corps of Engineers, and the U.S. Forest Service to protect water resources. Strict permitting is required for stream crossings, wetland crossings and timbering near these resources. Timbering companies also are required to develop extensive erosion and sedimentation control plans for areas they plan to timber. Through these relationships between timbering companies and agencies, the timber business continues to thrive while protecting our
invaluable water resources.

**Agriculture**

Farmers usually rely on groundwater wells or springs to provide drinking water for both their families and livestock. Because groundwater is buried beneath the earth’s surface, it is sometimes thought that groundwater is protected from contamination. That is not the case. Activities on the land surface, including improper agricultural practices, can harm groundwater quality. Pollution by nitrate (a form of nitrogen), bacteria and pesticides can cause health problems for human beings and livestock when these contaminants pollute a water supply.

Animal manure, commercial fertilizers and pesticides can also pollute surface waters if they are misused or applied in excess of crop needs. Much of sediment pollution in streams comes from eroding and unprotected stream banks. Fencing stream banks and limiting livestock access with crossings promotes the establishment of a healthy vegetative cover. Forested vegetation along streams, called riparian forest buffers, helps stabilize stream banks in reducing erosion and collapse. These buffers can also help trap soils and pollutants that may otherwise run off of adjacent fields into the waterways.

**Forestland and Farmland Conversion to Developed Land**

Only about 9,600 of Pennsylvania’s 58,000 farmers have sales of $100,000 or more. The cost to produce quality agriculture goods consumes nearly 85 percent of sales, leaving most farmers with a net farming income below $19,806, from which a 12.4 percent self-employment tax must be calculated. For a family of four, this net income is below the poverty level (based on 2006 figures). As a result, many farms in the commonwealth have been sold to housing developers in the past years. This movement is largely due to rising taxes and land prices, reflecting a high demand for land.

A map showing future population projections in the Upper/Middle Susquehanna Region is on insertPage#.

Many older towns and cities throughout Pennsylvania are currently losing population as people continue to settle in suburban and rural housing in areas that were once forest or farmland. During the 1990s, the total number of acres developed in Pennsylvania increased by 53.6 percent, while Pennsylvania’s population grew by only 3.4 percent. The aerial photographs on this page illustrate the landscape changes that have occurred in the Upper/Middle Susquehanna Region over time. Both photographs were taken between Wilkes-Barre and Laurel Run. The 1939 photograph already shows substantial development; however the 2005 photograph illustrates the continued expansion of Wilkes-Barre to the south. Areas that appear to be either excavated for mining or a potential landfill in 1939 have been converted for residential, commercial and industrial land use. As well, I-81 was added to the landscape.

The relationship between development patterns and water resources is complex. Since Pennsylvania recommends a watershed approach to managing water resources, it’s critical that the local decision-making framework consider water resources and land uses within the entire watershed area when planning for growth and development.

A watershed approach broadens the geographic planning area...
Beyond political boundaries and extends it to the hydrological boundaries of the watershed. Protecting and managing water resources at the broader watershed scale are likely to require inter-municipal cooperation.

Evaluating the percent of impervious cover in a watershed can be a useful indicator in planning future growth and development. Impervious surfaces, which prevent water from flowing through them and into the groundwater system, include roads, parking lots, rooftops, driveways and sidewalks. The Impervious Surface Map on the previous page shows impervious surfaces based on land use/land cover in the Upper/Middle Susquehanna Region. Areas of impervious cover are centered around cities and towns as well as corridors connecting these locations. Developed lands are more prominent in the southern and southeastern portion of the region, from the Scranton-Wilkes-Barre area to State College.

Research has shown a strong inverse relationship between the percent impervious cover and water quality and stream health. However, the location of impervious cover within a watershed is another variable that needs careful consideration. For example, in an attempt to protect water quality by limiting impervious cover, many local governments have mistakenly applied impervious cover thresholds to individual sites within a watershed by adopting low density zoning districts, thereby encouraging scattered low density development.

Used alone, low density development consumes more land and generates more stormwater runoff than the same number of homes accommodated under a higher density scenario in a given watershed. (See Illustration on previous page.) In other words, when measured by the house, higher densities produce less stormwater runoff.

When runoff is measured by the acre, limiting density does minimize water quality impacts compared to higher-density scenarios. However, when measured by the house, higher densities produce less stormwater runoff. (Source: Protecting Water Resources with Higher-Density Development, EPA, 2006)

Higher density development — more people on less land — can effectively protect water resources if it occurs within the framework of a more encompassing watershed strategy that considers other factors, such as the location of old and new development, preservation of critical natural lands and the use of site-specific stormwater management practices.

In some situations, low density development can be a tool to preserve agricultural and forest lands if it too reflects a watershed strategy and includes such elements as the protection of water supply protection areas, streamside buffers and floodplains, or critical ecological habitats.

When planning for future growth that will be protective of water resources, it’s important that local governments use a wide range of land use strategies, based on a sound understanding of local watershed hydrology, assessment of undeveloped lands and local housing and infrastructure needs.

For more information on smart growth techniques, EPA’s Protecting Water Resources with Smart Growth provides an excellent overview of how communities have minimized the impacts of new development on water resources through effective planning policies and site-level practices. Visit www.epa.gov/smartgrowth.

Land Use Planning for Water Resources
Planning for adequate supplies of clean water is just as important as planning for roads, businesses and schools. In recognition of this fact, the Municipalities Planning Code (MPC), the enabling state legislation that empowers local governments to plan and regulate land use, was amended in 2000 to require the inclusion of a plan for the reliable supply of water in the preparation of local comprehensive plans.

Nearly 1,200 municipalities have adopted comprehensive plans to guide future land uses. More importantly, the number of municipalities engaged in cooperative, multi-municipal planning (permitted under the MPC since 2000) is growing – 760 municipalities and counties were involved in 207 multi-municipal comprehensive plans in 2005.

Collaborative planning is essential to sound water use planning since water almost always crosses political boundaries. By planning at a watershed scale, local government leaders can take advantage of the many land use tools that are particularly useful in protecting the long term supply and quality of water.

For example, a multi-municipal approach provides for joint zoning ordinances. Instead of each municipal government providing for every land use, joint zoning allows neighboring governments an opportunity to integrate land uses. A joint overlay zone may protect a wellhead protection area that crosses municipal lines. An agricultural district may make more sense in one municipality where prime farmland dominates, while higher density development can be better accommodated in another municipality where the soils are less productive.

Many more land use planning tools, adopted jointly or individually, are at the disposal of local government officials who recognize the need to protect water resource lands and allow for growth and development. Examples include:

- Effective agricultural zoning
- Transfer of development rights
- Conservation easements on agricultural or forested land (purchased or donated)
- Overlay zones to protect wellhead protection areas, streamside buffers
- Green infrastructure planning
- Conservation subdivision or open space design
- Traditional neighborhood development
- Infill and redevelopment incentives
- Site-level development regulations that reduce impervious cover and infiltrate and/or treat stormwater runoff

All of these land use planning tools are most effective when applied within the framework of local watersheds. It is up to municipal governments to integrate watershed strategies in their comprehensive plans and regulations in order to protect our water resources.
History of Water Supply and Wastewater Treatment in the Upper/Middle Susquehanna

Early development in the Upper/Middle Susquehanna Region occurred in the Wyoming Valley where agriculture and later coal became big industries. In the late 18th and early 19th centuries, anthracite coal in the region attracted the attention of entrepreneurs which led to industrial and urban development along the Susquehanna and Lackawanna rivers. Rapid development of industry and communities in the area led to degradation of surface and groundwater quality.

During the mid-19th century the city of Scranton was no longer able to use the Lackawanna River as a drinking source because it was declared unfit for public supply. This was largely due to untreated wastewater from sewer systems and coal mines discharged into the Lackawanna River and ultimately into the Susquehanna River. It was during this same time that water companies formed and developed water supply reservoirs in the region. Several reservoirs created along the Moosic and West mountain ranges during the 19th century are still in use today. Although recognition of declining water quality occurred in the 1860s, it would take almost another century before wastewater improvements were made in the region.

In the 1960s, Pennsylvania’s Sanitary Water Board began ordering the construction of wastewater treatment plants for communities in the region. During this time, small cities like Wilkes-Barre were contributing more than 15 million gallons of untreated wastewater a day to the Susquehanna River.

Meanwhile, mining operations in the region directly discharged wastewater from mines into the Susquehanna River and its tributaries. In 1961 below the town of Wilkes-Barre, a single mining company discharged 25 million gallons of wastewater a day into the Susquehanna River. The result of directly discharging untreated mine wastewater was a 55-mile stretch of the river littered with dead or dying fish. After events such as this, the commonwealth began to require mining companies to build wastewater treatment plants to treat mine wastewater. While mining was large in the anthracite coal region of the Wyoming Valley, bituminous coal was abundant in the West Branch of the Susquehanna River subbasins. In this bituminous area similar mining practices led to surface and groundwater quality degradation much like that of the Wyoming Valley.
The Upper/Middle Susquehanna Region Today

It was because of past problems that Pennsylvania has worked hard with industries and communities to restore water quality in the region. Several communities in the region have together created sewer or sanitary authorities to maintain and operate wastewater treatment facilities. For example the Wyoming Valley Sanitary Authority is composed of 14 municipalities and provides wastewater treatment in Luzerne County. Today the Upper/Middle Susquehanna Region has seen many fish and aquatic life return in healthy numbers to its streams because of advancement in wastewater treatment.

The Public Water Service Map on the following page depicts population density throughout the Upper/Middle Susquehanna Region in relation to areas served by public water suppliers. Each dot on the map represents 200 people living in the municipality (2000 Census). The dots are randomly placed within the municipality boundaries and do not represent the exact location of people living in a township, town or city. As the map shows, densely populated areas, represented by dots so close together that they form a solid color block, are generally served by public water supplies. Scranton, Wilkes-Barre, Bloomsburg, Williamsport and State College are population centers that are serviced by public supply areas. In addition, Montrose, Bellefonte, Lock Haven and Clearfield also have concentrated service areas. The sources of public water supplies are groundwater, lakes, reservoirs, rivers and streams. Sparsely populated areas, where the dots are farther apart, are not included in the public supply service areas, and residents must find private sources of water, such as residential wells that tap into groundwater, to meet their water needs.

Wastewater treatment service areas typically mimic those of public water service areas. Typically, public service areas are highly urbanized and cannot accommodate on lot private septic systems. Limited available open space and high concentrations of people nearly always require public wastewater treatment.

Public Water Resources

Groundwater

Groundwater wells supply drinking water to many municipalities and private residents in the region. Large groundwater withdrawals in the Upper/Middle Susquehanna Region occur primarily in the lower western section of the basin. In Centre County a large carbonate aquifer helps serve the State College area with drinking water. Mining of calcium limestone in the State College area has reduced sections of the aquifer that collect water runoff from the surrounding mountain slopes.

Lakes and Reservoirs

The Upper/Middle Susquehanna Region has many lakes and reservoirs that provide drinking water, flood control and recreational use. Lakes throughout the basin are maintained by state agencies like the DCNR, federal agencies like the ACOE, or the FBC. Lakes such as the 198-acre Lackawanna Lake located in Lackawanna County or the 389-acre Rose Valley Lake in Lycoming County are maintained by the DCNR and FBC, respectively. The U.S. Army Corps of Engineers maintains several lakes in the region such as Cowanesque Lake in Tioga County and Curwensville Lake in Clearfield County. Lakes and other impoundments can be regulated and maintained by private entities, as well.

Rivers and Streams

The 18,295 square miles of the Upper/Middle Susquehanna Region contains many streams and rivers that are utilized for water supply and recreation. For example, the town of Bloomsburg in Columbia County receives its drinking water from Fishing Creek. Public water supply intakes can also be found along the North and West Branch of the Susquehanna River.

The West Branch of the Susquehanna River has many stretches of its headwaters classified as high quality or exceptional value. As it winds its way through...
many deep canyons and rural settings, it retains its high quality. However, many small tributaries have been negatively affected by abandoned mine drainage. Just like other areas in the Upper/Middle Susquehanna Region, water treatment plants are used to provide communities with quality drinking water and mitigate for the negative effects of contaminants. Thanks to many federal and state driven efforts and the commitment of many individuals, the waterway is improving. In recognition of these efforts, the West Branch of the Susquehanna River was named DCNR’s “River of the Year” for 2005.

Drinking Water
Like all living organisms, humans need water to survive. Whether a person lives in a single family home in the country or a large metropolitan city, water supplies support daily life. Public drinking water may be supplied by a publicly-owned or privately-owned company while private drinking water is usually supplied by an on-site well. In some cases, water supplies require purification before human consumption. This purification is done to ensure that all harmful materials are extracted or minimized so not to adversely affect human beings.

Public Water Treatment
Water treatment for most urban and suburban centers involves a process of filtration, disinfection and distribution of purified water. The first process in filtration, coagulation, involves adding selected chemicals that stick to particles in the water and make them heavy. As the particles become heavier they drop to the bottom, which is known as precipitation. Water is then filtered to remove the precipitate. During the filtering process, the water passes through layers of sand, gravel and charcoal that removes even smaller particles. Next, disinfection is accomplished by injecting chlorine or ozone into the filtered water. Chlorine is the most common form of disinfection because it has a residual effect, meaning it will remain in the water through the distribution system. Depending on where the source water to the aquifer comes from, groundwater resources may also require treatment for removal of organics and metals. The final aspect of water treatment is distribution in which the treated water is sent through piping systems to homes, businesses and industries or to a storage facility for later use.

Scranton, the largest city in the Upper/Middle Susquehanna Region, treats and purifies an average of 18 million gallons a day but is capable of processing up to 33 million gallons a day. It is important for urban areas to be flexible and able to treat large volumes of water to address population changes that can happen for various reasons. State College, for example, experiences very large, short-term population changes during football season when the Penn State Nittany Lions host games in Happy Valley. On average, more than 100,000 visitors attend the home games on a regular basis. These huge influxes of people could consume large quantities of publicly-supplied water, contrasting a typical day.

The water treatment facility for the city of Scranton and its surrounding communities follows the same basic form of treatment of filtering, disinfecting and distributing clean water. For Scranton and its communities, the clean water flows through a distribution system to approximately 135,000 residents. Other urban centers in the Upper/Middle Susquehanna Region like Wilkes-Barre, Williamsport, State College and Bloomsburg use similar methods of water treatment.

Private Well Water Treatment
Rural areas, common in the northern parts of the Upper/Middle Susquehanna Region, extract water from private wells. Homeowners with private wells have a variety of options for filtration and water softening systems that remove mineral particles from well water. The system selected usually depends on the amount of water a private residence uses per day as well as the most common types of contaminants necessary to filter from the water source. Fortunately for most private well users, little treatment is usually needed as a large portion of groundwater is unaffected by contaminants that typically affect surface water. Information on home water systems and contaminants can be obtained from the DEP, EPA, Center for Disease Control or the National Sanitation Foundation International.

Source Water Protection
Pennsylvania, like all other states in the U.S., is required to ensure that healthy drinking water is available for its citizens through compliance with the Safe Drinking Water Act (For more information visit: www.epa.pa.gov). Other federal and state laws, including the Water Resources Planning Act which prompted the creation of this atlas, lay the groundwork for water planning and protection. (Water laws and regulations are discussed in the Statewide Overview Section of this atlas.)

Since the Upper/Middle Susquehanna Region supplies several large communities with drinking water, protecting these resources has become paramount for the commonwealth. Groundwater, rivers and lakes in the region face potential contamination from a number of sources, such as development, agriculture, old septic systems, waste disposal sites and abandoned mines. Pennsylvania state agencies are working with organizations in the Upper/Middle Susquehanna Region to help assess the health of surface water and groundwater, identify point and nonpoint sources of pollution, prevent contamination, restore degraded waters, preserve pristine waters, increase public awareness of existing problems and help the public utilize best management practices.

Although federal and state level agencies are creating new policies, source water protection must literally begin at the source. Local governments – counties and municipalities – have the greatest opportunity to influence the future of Pennsylvania’s water supply. By studying their water sources, identifying areas of concern or hazards that threaten those sources, developing water protection and conservation regulations, and implementing those regulations, local governments can protect water supplies for future generations. Many Pennsylvania counties in the Upper/Middle Susquehanna Region are rising to this challenge.

- Centre County’s Conservation District sponsors annual conferences, tours and workshops for builders, residents and farmers. Events sponsored by the Centre County Conservation District examine farming best management practices and sediment and erosion control practices for builders and land developers in the county.
- Lycoming County has adopted a comprehensive plan for use by its municipalities for community development. The Lycoming County
Comprehensive Plan provides guidance on land use, infrastructure, transportation, housing and community development, all of which can affect water quality and use.

Lackawanna County’s Conservation District provides a four row no-till corn planter and a no-till drill for rent. The equipment available for rent is part of Lackawanna County’s no-till farming program which helps to reduce soil erosion, increase organic material in the soil and increase long term yields.

Importance of Forested Areas to Water Supplies

Forested areas are critical to the water supply. Wetlands, vegetated areas and forests along streams act as natural filters of soils and pollutants. The importance of these vegetated areas along streams, known as riparian buffers, is largely overlooked. These areas, along with natural filtration, provide protection from erosion, allow excess water to be reabsorbed, and provide unique habitat to many plants and animals.

Forests sequester carbon, helping to reduce the amount of carbon dioxide in the atmosphere. The forested areas that surround many streams and rivers also provide benefits to the waterways. Specifically, hemlocks are common residents of riparian areas that are beneficial by providing habitat and beneficial shade. Their dense canopies provide shade to streams which regulate stream temperatures providing an ideal ecosystem for many coldwater inhabitants, including brook trout. The loss of these hemlocks would be detrimental to many aquatic species as well as the species that live in and among the trees.

The map on the following page shows the region’s forested areas. The Upper/Middle Susquehanna Region supports hardwood forests including pine-oak and oak-hickory forests, as well as coniferous (that is, trees that produce cones and have needles such as pine trees) forests, including Eastern hemlock. This region is mainly...
comprised of deciduous (that is, trees with leaves that fall when autumn arrives) forest type, with 50 percent deciduous and 20.5 percent mixed and coniferous forest types. As illustrated in the Forested Areas Map on the next page, the most densely forested areas are located in the eastern areas of the region. These areas benefit tremendously from the forest cover as it provides protection to surface waters, such as headwaters to the West Branch of the Susquehanna and source water protection for groundwater supplies. More information about the Upper/Middle Susquehanna Region’s forests is provided on the Land Use pages of this Upper/Middle Susquehanna Region section of the atlas.

Wastewater Treatment

Long before mankind appeared on the earth, natural biological processes had already found a means to deal with waste in streams. Once human beings began to evolve, they created small communities, towns and cities. As these population centers grew larger so did the amount of wastewater being generated by mankind. Natural biological processes were easily overwhelmed by humankind’s high outputs of wastewater.

It was not uncommon for older cities to fall victim to outbreaks of disease caused by pathogenic, viral, bacterial or protozoan organisms from untreated wastewater contaminating drinking water supplies. This was exemplified in 19th century London, England’s outbreaks of cholera that contaminated drinking water supplies and resulted in many deaths. It was because of harmful outbreaks like that in 19th century London that biologists, scientists and engineers developed methods for the treatment of wastewater.

When water leaves a private residence or business through a drain or toilet it travels to a septic tank or wastewater treatment facility. Wastewater treatment facilities follow a series of processes that screen, aerate and disinfect water.

Upper/Middle Susquehanna Region Public Education Programs

Municipality and community based organizations have become more involved with increasing public awareness on Upper/Middle Susquehanna Region water issues. More information can be found through the DEP or through the Water Resource Education Network.

- The Bradford County Conservation District assisted organizations holding workshops and providing incentives for homeowners to utilize on-lot septic system management practices. This was done in an effort to reduce pollution in the Susquehanna River and ultimately the Chesapeake Bay.
- In Cameron County, Emporium Borough and the Cameron County Conservation District designed and distributed brochures and public service announcements on reducing nonpoint source pollution and sedimentation in the Sinnemahoning Creek by managing forested lands.
- Clearfield County’s conservation district partnered with Clearfield County Senior Environmental Corps and Curwensville Lake Recreation Area to create a conservation festival. The festival encouraged outdoor activities that educated county citizens about protecting and restoring local surface waters in the West Branch of the Susquehanna River.
- The Sullivan County Conservation District paired with PA Rural Water Association to educate students and local citizens about surface and groundwater protection. This was accomplished through the use of educational equipment, brochures and other media.
- Tioga County’s conservation district in cooperation with several organizations gave water quality test kits to farmers who attended workshops on water quality. The workshops instructed farmers about water quality issues and non-point source pollution.

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Bellefonte gets its name from the same natural spring that supplies the town’s water. The spring was named by the wife of Charles Maurice de Talleyrand-Perigord, a French diplomat, during a visit to the area in the 1790s when she described the spring as a “Quelle belle fontaine,” or beautiful fountain.
before discharging it back into a stream or river or back into the groundwater supplies. The treatment process starts by screening any large debris from wastewater. The screened water is then aerated, which allows for natural biological processes to decay organic matter. Any solid material left in the tanks is then extracted and disposed of appropriately. The water is then disinfected, usually with chlorine, to kill any microorganisms that may be harmful to streams and rivers.

Public Wastewater Treatment
Pennsylvania has learned from history that discharging untreated sewage or industrial waste into the rivers and streams can have devastating results for its inhabitants and the natural environment. Just as high volume water purification facilities are needed to service urban centers and cities, so too are wastewater treatment facilities needed.

Fourteen municipalities in Luzerne County formed the Wyoming Valley Sanitary Authority (WVSA) which operates one of the largest wastewater treatment facilities in the Upper/Middle Susquehanna Region. Currently the WVSA serves about one-quarter of a million people and treats an average of 25 million gallons of wastewater per day. The majority of wastewater treatment facilities in the Upper/Middle Susquehanna Region are along the lower section of the watershed, as is also the case for public water supply service areas.

Private Wastewater Treatment
Private residences in some suburban and most rural areas of the Upper/Middle Susquehanna Region commonly use private septic systems. Typical private septic systems allow for wastewater to flow to an underground tank. Once in the tank, heavy particles fall to the bottom while water can flow out of the top of a tank and into a drain field pipe. Once in the drain field pipe the remaining wastewater is dispersed into a drain field where it slowly permeates down through the soil.

Unfortunately, malfunctioning on-lot septic systems can be a significant source of groundwater pollution in these rural communities. DEP is continually researching innovative technology that aids in the most effective way to reduce pollution from private septic systems. For more information on the latest technology, see www.depweb.state.pa.us under “DEP Programs–Wastewater Information.”

Sources of Groundwater Contamination
Soil normally filters contaminants out of surface runoff before it reaches groundwater reserves. However, sometimes the contaminant is released directly into the ground and not enough soil lies between the source and groundwater to act as an effective filter. Other times, the contaminants may be released in such a large amount that the soil cannot remove all of the contaminants. The following is a list of common groundwater contaminants and their sources:

- Bacteria and viruses in untreated sewage leaking from damaged sewer lines or malfunctioning septic systems
- Toxic materials improperly disposed of down drains or into landfills
- Gasoline and petroleum products leaking from storage tanks or improperly disposed (e.g., dumping used motor oil on the ground)
- Fertilizers, herbicides and pesticides used in excess amounts on farms, orchards and home gardens and lawns
- Acid mine drainage from coal mining operations
- Radioactive substances (uranium, radium and radon) naturally found in soil and rocks
Forested Areas

Upper/Middle Susquehanna Region Forested Areas

P E N N S Y L V A N I A
N E W Y O R K

City/Town
County Boundary
State Boundary
Deciduous Forest
Evergreen Forest
Mixed Forest

0 5 10 15 20 25 Miles

0 50 100 150 200 250 300 Miles

Upper/Middle Susquehanna Draft
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The Susquehanna is many rivers in one. A ten-day voyage will take the canoeist through coal country, a wild canyon, small towns, fertile farmland, the state capital, hydroelectric dams and finally the coastal plain and Chesapeake Bay.” —Tim Palmer, author of “Rivers of Pennsylvania”

Combined Sewage Overflows

The Upper/Middle Susquehanna Region has been faced with many environmental issues that have compromised water quality in the past. One of the most prominent sources of impact is the outdated sewage treatment facilities along the Susquehanna River. In the past century, 225 combined sewage overflows have been recorded, unloading into the river untreated human sewage mixed with stormwater during heavy rainfall.

Local municipalities have taken strides to replace outdated sewage treatment facilities to reduce and eliminate sewage overflow during storm events. Also, a partnership between state and local teams have been funded to implement new safety measures, including water monitoring with GIS instruments. A real time measurement of the water quality data is available at the Pennsylvania Geographic Information System’s Web site: www.pagis.org.

A homeowner’s responsibility for maintaining a private septic system is important for his or herself as well as the environment and anyone living nearby. A properly working septic system protects groundwater resources, the land and soil that the system operates on, and also preserves the monetary value of a property.

Proper maintenance of a private septic system starts with what is flushed through the system. Bathroom and household products such as paper towels, dental floss, cigarette butts and feminine hygiene products can clog and possibly damage the different components of a septic system. Eliminating such items from entering the septic system prevents any damage to the pipes and pumps that carry the waste to the septic tank.

Regular pumping (generally every three to five years) of the septic tank helps maintain a properly working system. The septic tank allows solids (sludge) to settle out of the wastewater to decompose and allows oil and grease (scum) to float to the surface. If the tank is allowed to fill with sludge and scum, clogs may occur and the wastewater will not properly drain to the drain field. As mentioned, this is easily avoided if the tank is pumped on a regular basis.

Once exiting the septic tank, the wastewater enters a drain field where microbes in the soil remove and digest harmful bacteria, viruses and nutrients. The soil is a natural filter for the septic system and is an equally important step in a properly functioning private septic system. Drain fields should only be planted with grass, as tree roots and shrubs may clog and damage the pipes in the drain field. Also, eliminate driving or parking vehicles on the drainfield as this will compact the soil or damage the pipes, tank and other components to the system. Care should also be taken not to flood the drainfield with excess wastewater. Eliminate other drainage systems, such as sump pumps, rain water or french drains from discharging to the drain field. Excess water can stop the treatment process or cause plumbing fixtures to back up.

By following these simple steps, private homeowners can maintain a properly working septic system. More information can be found by contacting the local health department or visiting the U.S. Environmental Protection Agency (EPA) at http://cfpub.epa.gov/owm/septic/index.cfm.
Water-Based Economy

Manufacturing, agriculture, electricity generation and recreation are major business sectors in the entire Susquehanna River Basin. All of these sectors rely on water—either directly or indirectly—to support their livelihood.

Electricity Generation
The entire Susquehanna River is a major supplier of electricity for the basin. Hydroelectricity plants are common in the Lower Susquehanna River while nuclear and coal-fired steam stations are prominent along the Upper Susquehanna and its major tributary, the West Branch of the Susquehanna River.

- The Susquehanna Steam Electric Station is located on the Susquehanna River, near the town of Berwick. Unit 1 has been operating since 1983 and has a capacity of 1,135 megawatts while Unit 2 has been operating since 1985 and has a capacity of 1,140 megawatts. In 2005, the Susquehanna Steam Electric Station generated about 18 million megawatt-hours of electricity, accounting for eight percent of the electricity generated in the commonwealth every year. The plant is operated by PPL Susquehanna LLC and owned by PPL Inc. and Allegheny Electric Cooperative Inc.

- The Shawville Electric Generating Station is located on the West Branch of the Susquehanna River near the town of Clearfield. The coal-fired electricity generator has a capacity of 572 megawatts. The plant is owned by Reliant Energy.

- The Montour Steam Electric Generation facility is located near the West Branch of the Susquehanna River, a mile northeast of Washingtonville. Originally built in the 1970s, the two units of the coal-fired electricity generator have a combined capacity of 1,525 megawatts. The plant is owned by PPL Generation LLC.

Agriculture
The Upper/Middle Susquehanna Region has continually contributed to Pennsylvania’s agricultural foundation. The region’s vast size and relatively rural setting has allowed agriculture to flourish. One of the most important crops for raising cattle and dairying, hay, is produced in large amounts in the Upper/Middle Susquehanna Region. Bradford, Susquehanna and Tioga counties all produce 150,000 tons of hay or more, placing them in the top five of hay producing counties in the state.

According to the National Agriculture Statistics Service (NASS), Bradford County ranks number one in Pennsylvania for forage — land used for all hay and haylage, grass silage and greenchop. The county also contains large herds of cattle and calves with nearly 30,000 head of cattle being raised in the

Did you know?
World’s End State Park hosts a slalom race on the Loyalsock Creek every spring that draws crowds and competitors from all over the east.

Fishing, Centre County.

Elk Mountain Ski Resort, Uniondale Susquehanna County.

Knoebels Grove Amusement Park, Elysburg, Northumberland County.
county. Tobacco, another significant crop of value, is produced in the region as well as the state. Clinton County produces a large amount of tobacco as a cash crop, ranking third in the state in value of sales.

Dairy operations in the Upper/Middle Susquehanna Region also contributes to the state’s overall production of milk and dairy products. Numerous counties within the region consistently produce more than 100 million pounds of milk per year with some counties producing more than 250 million pounds a year!

Manufacturing
The Upper/Middle Susquehanna Region’s heavily forested areas arguably provide Pennsylvania with perhaps its largest supply of production grade hardwood timber. The production and manufacturing of export grade hardwood is one of the state’s most important commodities. Pennsylvania ranks number one among all other states in the production of export grade hardwood, consistently generating sales of more than $5 billion annually from its hardwood industry.

The region’s abundant forests of red maple, black cherry and oak varieties make it a prime source for manufacturing wood products. Furniture and cabinetry are just two of the many products that are manufactured within the region. Other exports of paper and allied products generate revenue for the region. Pennsylvania’s laws and regulations help protect the bountiful water resources commonly associated with the timbered areas of the Upper/Middle Susquehanna Region. These laws allow timbering to remain successful while preserving our water resources.

Fisheries and Hatcheries
The decades following the American Revolution saw prosperous shad harvests in the Upper/Middle Susquehanna Region, limited only by the availability of salt used in its preservation. Although river herring (alewife and blueback herring) were also abundant, shad was considered the most valuable aquatic resource of the region, selling for between three and 20 cents apiece in the early 1800s. Booming shad and herring fisheries declined with the construction of dams along the river for mills, the canal system and electricity generation. These dams prevented shad and herring from migrating upstream.

In late 2003, Pennsylvania Governor Ed Rendell launched the Pennsylvania Wilds initiative to encourage the growth of tourism and boost the economy in northcentral Pennsylvania. This region of the state encompasses 6.5 million acres, including 5.2 million acres of forestland. The goal of the initiative is to enhance visitor experiences in the Wilds, while protecting and conserving the treasured natural resources.

Within the Wilds region, there are 27 state parks, the Allegheny National Forest and many game lands. Adventurous tourists can enjoy a variety of outdoor pursuits, including hiking on the Pine Creek Trail, snowmobiling on designated trails, cross-country skiing and horseback riding. Others can take in the lush scenery, filled with the largest herd of elk in the northeast, or view the darkest skies in the east at Cherry Springs State Park.

The majestic beauty of the Pennsylvania Wilds is anticipated to become one of the top travel destinations in the state, as tourism is the second-leading industry. The initiative is targeted toward outdoor enthusiasts and those who look to escape urban lifestyles to explore the great outdoors.

Great economic potential spurs the approximately 660,000 residents of the Wilds region. These communities have struggled to thrive since railroading, oil and other industries have subsided. Bringing tourists to this region will provide an opportunity to build economic gain with the need for overnight accommodations, guides, eateries and outfitters. In fact, in 2006 an Intergovernmental Cooperative Agreement was signed, allowing for the Pennsylvania Wilds planning team to receive state funding. This initiative boosted the region’s potential to grow and capitalize from the tourism brought in by the Pennsylvania Wilds.

For more information, go to www.pawilds.com
Starrucca Viaduct

Built in 1848, the Starrucca Viaduct was thought to be the most expensive and the greatest work of railroad bridge masonry in the United States. At 1,200 feet long, 110 feet high, the bridge crosses Starrucca Creek near Lanesboro, Pennsylvania.

In the mid-19th century, the viaduct was constructed to allow for continuous railways through Pennsylvania. The Starrucca Creek was considered a particularly difficult area, with a sudden deep and wide depression in the hills. Julius W. Adams and James P. Kirkwood were hired to design the viaduct, and it was constructed by New York and Erie Railroad. The viaduct was built of locally-quarried ashlar bluestone with a brick interior and concrete base. Eight hundred workers were paid about $1 per day, and the bridge was completed in about a year.

Continually used for more than 150 years, the Starrucca Viaduct is part of the Norfolk Southern Railway and operated by Central New York Railway. The viaduct was built of locally-quarried ashlar bluestone with a brick interior and concrete base. Eight hundred workers were paid about $1 per day, and the bridge was completed in about a year.

Recognizing the threat that a nonexistent shad industry would have on Pennsylvania’s economy, the state has been making strides to reverse the effect of the water obstructions. Small dams once built to supply water for mills, industrial needs, municipal water systems and recreation as well as road crossings and stream culverts have been removed or reconstructed where possible to restore the natural flow of the river and its tributaries. The hydroelectric dams of the Lower Susquehanna have constructed fish passage facilities to enable the migration of shad and other fish species upstream. More than 450 miles of the Susquehanna River main stem, West Branch, and Juniata River have been “reopened” to fish migration.

The Pennsylvania Fish and Boat Commission estimates that recreational shad fishing on the river will result in $30 million annually in economic benefit.

As shad begin to return to the Upper/Middle Susquehanna Region, anglers are drawn to the region for fishing of other species as well. In order to maintain a thriving recreational fishing industry, the Pennsylvania Fish and Boat Commission operates 15 state fish hatcheries used to stock Pennsylvania waters. There are four hatcheries in the Upper/Middle Susquehanna Region. The highlight box on the next page provides more information about the hatcheries.

Recreational Areas

The Upper/Middle Susquehanna Region contains five of the 20 “Must-See State Parks” designated by the Pennsylvania Department of Conservation and Natural Resources as the best examples of significant natural and historic resources in the commonwealth. Three of these state parks are popular destinations for kayaking, canoeing, boating, fishing, swimming and winter activities.

Fish Hatcheries

The Upper/Middle Susquehanna Region boasts four of the 15 state fish hatcheries in Pennsylvania. These centrally located hatcheries are operated by the Pennsylvania Fish and Boat Commission and aid in the state’s plan for rural economic growth.

The four hatcheries in the Upper/Middle Susquehanna Region are located in State College, Bellefonte, Pleasant Gap and Tylersville. The facilities include indoor and outdoor raceways, egg incubators, pools and warming ponds. Water sources for the hatcheries vary from private springs, production wells and reservoirs. Various species of trout including brook, brown, rainbow and golden rainbow are raised in these hatcheries along with purebred muskellunge, tiger muskellunge and walleye. All together, the four hatcheries provide Pennsylvania with more than 2.2 million fish and boost the state’s economy $261 million annually.

In addition to the fish and revenue, the hatcheries benefit local rural communities. The four hatcheries combined provide 64 sought-after employment positions. Also, two of the four hatcheries have community centers where visitors learn more about the hatchery system, eat at local restaurants and stay in area hotels, creating economic gain for nearby communities. All together, the hatcheries are important facilities for many people, and while funding is sometimes hard to come by, the commonwealth is working to increase state financial support.

For more information, visit www.fish.state.pa.us

Winter, Ricketts Glenn State Park.
awareness and conservation and have been highlighted in publications all over the country. Canoeists and kayakers have paddled the river in hopes of spotting different species of birds and animals that call the river home, with one of the most prominent being the Bald Eagle. Other individuals enjoy the river’s bountiful supply of game fish, such as smallmouth bass, muskellunge and walleye. The use of flat-bottomed john boats, canoes and even kayaks allow fishing enthusiasts to pursue their quarry. Along with fishing, outdoor adventurers can follow the many hiking trails that parallel the river while bird watching or simply getting in some exercise.

- **Black Moshannon State Park** (Centre County) consists of 3,394 acres of forests and wetlands surrounded by 43,000 acres of Moshannon State Forest. The park is the site of the Black Moshannon Bog Natural Area, the largest reconstituted bog/wetland complex in Pennsylvania. The 250-acre Black Moshannon Lake is used for swimming, boating and fishing for warm water species while Black Moshannon Creek supports trout fishing. Winter activities include ice skating, ice fishing and ice boating on the lake as well as snowmobiling and cross-country skiing.

- **The 13,050 acres that constitute Ricketts Glen State Park** (Luzerne, Sullivan and Columbia counties) include Glens Natural Area (a National Natural Landmark), 22 named waterfalls and the 245-acre Lake Jean. The lake is popular for swimming, boating and fishing for warm water game fish, panfish and trout. Winter activities include cross-country skiing, snowshoeing, ice fishing, snowmobiling and ice climbing.

- **The 780 acres of World’s End State Park** (Sullivan County) offers many water-based recreation activities along Loyalsock Creek, which carves a valley through the park. A small dam on the creek creates an impoundment for swimming. The cold mountain water of Loyalsock Creek provides good trout fishing for most of the year as well as white water boating opportunities. Winter sports in the park include snowmobiling and cross-country skiing.

For more information on national and state parks, see DCNR’s “Pennsylvania State Parks” Web site: www.dcnr.state.pa.us/stateparks/index.aspx and the National Park Service Web site: www.nps.gov
An extremely popular tourist destination in the autumn months, the Pine Creek Gorge, otherwise known as the Pennsylvania Grand Canyon, showcases stunning foliage in an array of reds, purples and yellows annually. The Pine Creek Gorge is located in Tioga State Forest and runs about 47 miles south of Wellsboro. The gorge is deepest at Waterville, where the canyon falls 1,450 feet. A product of the ice age, the Pine Creek Gorge was carved out by an overflowed Pine Creek due to glacial meltwater about 20,000 years ago. Since then, the deep channel has served as a travel route for Native Americans, as well as a variety of animals. White tail deer, beaver, turkey, black bear, river otter and even the once endangered bald eagle can be spotted in the gorge.

At the foot of the canyon, the Pine Creek Rail Trail follows Pine Creek for 64 miles from Ansonia in Tioga County to Jersey Shore in Lycoming County. Once a fully functioning railroad, the rail trail now allows hikers and bikers to see waterfalls, rock formations and other natural sites as they travel the trail. The last train ran through the gorge in 1988.

Water Trails
Water trails are recreational corridors suitable for canoes, kayaks and small motorized watercraft. These trails are comprised of access points, boat launches, day use sites and in some cases overnight camping areas. Each water trail is designated by the Pennsylvania Fish and Boat Commission as a unique reflection of the state’s diverse geology, ecology and communities.

The Upper/Middle Susquehanna Region includes three water trails:

- West Branch Susquehanna River Water Trail – 240 miles from Cherry Tree to Sunbury
- North Branch Susquehanna River Water Trail – estimated 166 miles from the New York Border to Sunbury
- Pine Creek – 54 miles from Ansonia to Torbet Canoe Access

For more information on Pennsylvania’s Water Trails, see the Pennsylvania Fish and Boat Commission’s “Water Trails” Web site: www.fish.state.pa.us/watertrails

Elk Watching
Now boasting one of the largest herds east of the Mississippi River, Pennsylvania has become a popular place for elk watching. More than 70,000 people come to various viewing sites around the region to view the elk. The best time of year to see elk are September and October, the annual mating period. The greatest numbers of elk are visible early in the morning and at dusk. Many viewing areas, including Winslow Hill in Benezette, Elk County, are staffed with guides to make the most of each viewing experience.

While viewing elk in their natural beauty is a wonderful opportunity, there are many safety precautions to be considered. First, viewing elk from a distance and not petting, feeding or chasing the elk is highly recommended to provide a natural habitat for the animals. Also, using the designated viewing areas is best, as stopping on the roadway, blocking driveways and entering private property is illegal.

The elk herd has provided many economic opportunities for the local residents. Nearby farmers, however, have not welcomed the herd as friendly visitors, as the elk have been known to trample over and eat crops. To protect the elk in Pennsylvania, as well as develop plans to alleviate agricultural tension and boost tourism, the state’s Department of Conservation and Natural Resources, the Pennsylvania Game Commission, and various local organizations have partnered to create the Pennsylvania Elk Watching and Nature Tourism project. Additional goals of the project are to provide a model for sustainable community development for the counties that make up the herd’s range.

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